US009193065B2

(12) United States Patent
Wang et al.

(10) Patent No.: US 9,193,065 B2
(45) Date of Patent: Nov. 24, 2015

(54) **DOCKING SYSTEM FOR A TELE-PRESENCE ROBOT**

(75) Inventors: **Yulun Wang**, Goleta, CA (US); **Charles S. Jordan**, Santa Barbara, CA (US); **Marco Pinter**, Santa Barbara, CA (US); **Daniel Steven Sanchez**, Summerland, CA (US); **James Rosenthal**, Santa Barbara, CA (US); **Amante Mangaser**, Goleta, CA (US)

(73) Assignee: **INTOUCH TECHNOLOGIES, INC.**, Goleta, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1274 days.

(21) Appl. No.: **12/218,259**

(22) Filed: **Jul. 10, 2008**

(65) **Prior Publication Data**

US 2010/0010672 A1 Jan. 14, 2010

(51) **Int. Cl.**

G05B 19/00	(2006.01)
B25J 5/00	(2006.01)
B25J 19/00	(2006.01)
G05D 1/02	(2006.01)
H02J 7/00	(2006.01)

(52) **U.S. Cl.**
CPC ***B25J 5/00*** (2013.01); ***B25J 19/005*** (2013.01); ***G05D 1/0225*** (2013.01); ***G05D 1/0242*** (2013.01); *G05D 2201/0206* (2013.01); *H02J 7/0042* (2013.01)

(58) **Field of Classification Search**
CPC combination set(s) only.
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,107,689 A		8/1978	Jellinek	
4,213,182 A		7/1980	Eichelberger et al.	
4,413,693 A		11/1983	Derby	
4,553,309 A		11/1985	Hess et al.	
4,572,594 A		2/1986	Schwartz	
4,625,274 A		11/1986	Schroeder	
4,638,445 A		1/1987	Mattaboni	
4,652,204 A		3/1987	Arnett	
4,669,168 A		6/1987	Tamura et al.	
4,679,152 A	*	7/1987	Perdue	701/23
4,697,278 A		9/1987	Fleischer	
4,697,472 A		10/1987	Hiyane	
4,709,265 A		11/1987	Silverman et al.	
4,751,658 A		6/1988	Kadonoff et al.	

(Continued)

FOREIGN PATENT DOCUMENTS

AU	1216200 A	5/2000
CA	2289697 A1	11/1998

(Continued)

OTHER PUBLICATIONS

F. Ando et al., "A Multimedia Self-service Terminal with Conferencing Functions", 1995, IEEE, pp. 357-362.

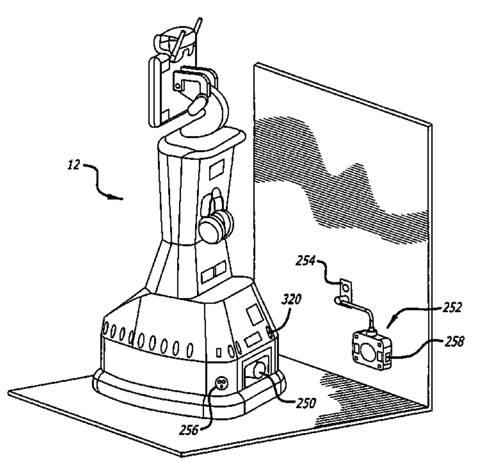
(Continued)

Primary Examiner — Jonathan L Sample
(74) *Attorney, Agent, or Firm* — Chris Lambrecht

(57) **ABSTRACT**

A remote controlled robot system that includes a mobile robot with a robot camera and a battery plug module, and a remote control station that transmits commands to control the mobile robot. The system also includes a battery charging module that mates with the mobile robot battery plug module, and an alignment system that aligns the battery plug module with the battery charging module. The battery modules may also be aligned with the aid of video images of the battery charging module provided to the remote station by a camera located within the battery plug module.

9 Claims, 11 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

4,766,581 A		8/1988	Korn et al.
4,777,416 A		10/1988	George, II et al.
4,797,557 A		1/1989	Ohman
4,803,625 A		2/1989	Fu et al.
4,847,764 A		7/1989	Halvorson
4,875,172 A		10/1989	Kanayama
4,878,501 A		11/1989	Shue
4,942,512 A		7/1990	Kohno
4,942,538 A		7/1990	Yuan et al.
4,953,159 A		8/1990	Hayden et al.
4,974,607 A		12/1990	Miwa
4,977,971 A		12/1990	Crane, III et al.
5,006,988 A		4/1991	Borenstein et al.
5,040,116 A		8/1991	Evans et al.
5,051,906 A		9/1991	Evans et al.
5,073,749 A		12/1991	Kanayama
5,084,828 A		1/1992	Kaufman et al.
5,130,794 A		7/1992	Ritchey
5,148,591 A		9/1992	Pryor
5,153,833 A		10/1992	Gordon et al.
5,155,684 A		10/1992	Burke et al.
5,157,491 A		10/1992	Kassatly
5,182,641 A		1/1993	Diner et al.
5,193,143 A		3/1993	Kaemmerer et al.
5,217,453 A		6/1993	Wilk
5,220,263 A		6/1993	Onishi et al.
5,224,157 A		6/1993	Yamada et al.
5,230,023 A		7/1993	Nakano
5,231,693 A		7/1993	Backes et al.
5,236,432 A		8/1993	Matsen, III et al.
5,262,944 A		11/1993	Weisner et al.
5,315,287 A		5/1994	Sol
5,319,611 A		6/1994	Korba
5,341,242 A		8/1994	Gilboa et al.
5,341,459 A		8/1994	Backes
5,347,306 A		9/1994	Nitta
5,350,033 A		9/1994	Kraft
5,366,896 A		11/1994	Margrey et al.
5,374,879 A		12/1994	Pin et al.
5,375,195 A		12/1994	Johnston
5,400,068 A		3/1995	Ishida et al.
5,413,693 A		5/1995	Redepenning
5,417,210 A		5/1995	Funda et al.
5,436,542 A		7/1995	Petelin et al.
5,441,042 A		8/1995	Putman
5,441,047 A		8/1995	David et al.
5,442,728 A		8/1995	Kaufman et al.
5,462,051 A		10/1995	Oka et al.
5,511,147 A		4/1996	Abdel-Malek
5,528,289 A		6/1996	Cortjens et al.
5,539,741 A		7/1996	Barraclough et al.
5,544,649 A		8/1996	David et al.
5,550,577 A		8/1996	Verbiest et al.
5,553,609 A		9/1996	Chen et al.
5,563,998 A		10/1996	Yaksich et al.
5,572,229 A		11/1996	Fisher
5,572,999 A		11/1996	Funda et al.
5,594,859 A		1/1997	Palmer et al.
5,600,573 A		2/1997	Hendricks et al.
5,617,539 A		4/1997	Ludwig et al.
5,619,341 A		4/1997	Auyeung et al.
5,623,679 A		4/1997	Rivette et al.
5,636,218 A		6/1997	Ishikawa
5,652,849 A		7/1997	Conway et al.
5,657,246 A		8/1997	Hogan et al.
5,659,779 A		8/1997	Laird et al.
5,673,082 A		9/1997	Wells et al.
5,675,229 A		10/1997	Thorne
5,682,199 A		10/1997	Lankford
5,684,695 A		11/1997	Bauer
5,701,904 A		12/1997	Simmons et al.
5,734,805 A		3/1998	Isensee et al.
5,739,657 A		4/1998	Takayama et al.
5,748,629 A		5/1998	Caldara et al.
5,749,058 A		5/1998	Hashimoto
5,749,362 A		5/1998	Funda et al.
5,754,631 A		5/1998	Cave
5,758,079 A		5/1998	Ludwig et al.
5,762,458 A		6/1998	Wang et al.
5,764,731 A		6/1998	Yablon
5,767,897 A		6/1998	Howell
5,786,846 A		7/1998	Hiroaki
5,787,545 A		8/1998	Colens
5,793,365 A		8/1998	Tang et al.
5,801,755 A		9/1998	Echerer
5,802,494 A		9/1998	Kuno
5,836,872 A		11/1998	Kenet et al.
5,838,575 A		11/1998	Lion
5,844,599 A		12/1998	Hildin
5,867,494 A		2/1999	Krishnaswamy et al.
5,867,653 A		2/1999	Aras et al.
5,872,922 A		2/1999	Hogan et al.
5,876,325 A		3/1999	Mizuno et al.
5,911,036 A		6/1999	Wright et al.
5,917,958 A		6/1999	Nunally et al.
5,927,423 A		7/1999	Wada et al.
5,949,758 A		9/1999	Kober et al.
5,954,692 A		9/1999	Smith et al.
5,959,423 A		9/1999	Nakanishi et al.
5,966,130 A		10/1999	Benman, Jr.
5,973,724 A		10/1999	Riddle
5,974,446 A		10/1999	Sonnenreich et al.
5,983,263 A		11/1999	Rothrock et al.
5,995,119 A		11/1999	Cosatto et al.
5,995,884 A	*	11/1999	Allen et al. 701/24
5,999,977 A		12/1999	Riddle
6,031,845 A		2/2000	Walding
6,047,259 A		4/2000	Campbell et al.
6,091,219 A		7/2000	Maruo et al.
6,113,343 A		9/2000	Goldenberg et al.
6,133,944 A		10/2000	Braun et al.
6,135,228 A		10/2000	Asada et al.
6,148,100 A		11/2000	Anderson et al.
6,160,582 A		12/2000	Hill
6,170,929 B1		1/2001	Wilson et al.
6,175,779 B1		1/2001	Barrett
6,189,034 B1		2/2001	Riddle
6,201,984 B1		3/2001	Funda et al.
6,211,903 B1		4/2001	Bullister
6,219,587 B1		4/2001	Ahlin et al.
6,232,735 B1		5/2001	Baba et al.
6,233,504 B1		5/2001	Das et al.
6,233,735 B1		5/2001	Ebihara
6,250,928 B1		6/2001	Poggio et al.
6,256,556 B1		7/2001	Zenke
6,259,806 B1		7/2001	Green
6,259,956 B1		7/2001	Myers et al.
6,266,162 B1		7/2001	Okamura et al.
6,266,577 B1		7/2001	Popp et al.
6,289,263 B1		9/2001	Mukherjee
6,292,713 B1		9/2001	Jouppi et al.
6,304,050 B1		10/2001	Skaar et al.
6,314,631 B1		11/2001	Pryor
6,317,652 B1		11/2001	Osada
6,317,953 B1		11/2001	Pryor
6,321,137 B1		11/2001	De Smet
6,324,184 B1		11/2001	Hou et al.
6,324,443 B1		11/2001	Kurakake et al.
6,325,756 B1		12/2001	Webb et al.
6,327,516 B1		12/2001	Zenke
6,330,486 B1		12/2001	Padula
6,330,493 B1		12/2001	Takahashi et al.
6,346,950 B1		2/2002	Jouppi
6,346,962 B1		2/2002	Goodridge
6,369,847 B1		4/2002	James et al.
6,373,855 B1		4/2002	Downing et al.
6,381,515 B1		4/2002	Inoue et al.
6,389,329 B1		5/2002	Colens
6,400,378 B1		6/2002	Snook
6,408,230 B2		6/2002	Wada
6,430,471 B1		8/2002	Kintou et al.
6,430,475 B2		8/2002	Okamoto et al.
6,438,457 B1		8/2002	Yokoo et al.
6,445,964 B1		9/2002	White et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,452,915 B1 9/2002 Jorgensen
6,457,043 B1 9/2002 Kwak et al.
6,459,955 B1 * 10/2002 Bartsch et al. 700/245
6,463,352 B1 10/2002 Tadokoro et al.
6,463,361 B1 10/2002 Wang et al.
6,466,844 B1 10/2002 Ikeda et al.
6,468,265 B1 10/2002 Evans et al.
6,470,235 B2 10/2002 Kasuga et al.
6,480,762 B1 11/2002 Uchikubo et al.
6,491,701 B2 12/2002 Tierney et al.
6,496,099 B2 12/2002 Wang et al.
6,496,755 B2 12/2002 Wallach et al.
6,501,740 B1 12/2002 Sun et al.
6,507,773 B2 1/2003 Parker et al.
6,522,906 B1 2/2003 Salisbury et al.
6,523,629 B1 2/2003 Buttz et al.
6,526,332 B2 2/2003 Sakamoto et al.
6,529,620 B2 3/2003 Thompson
6,529,765 B1 3/2003 Franck
6,529,802 B1 3/2003 Kawakita et al.
6,532,404 B2 3/2003 Colens
6,535,182 B2 3/2003 Stanton
6,535,793 B2 3/2003 Allard
6,540,039 B1 4/2003 Yu et al.
6,543,899 B2 4/2003 Covannon et al.
6,549,215 B2 4/2003 Jouppi
6,563,533 B1 5/2003 Colby
6,567,038 B1 5/2003 Granot et al.
6,580,246 B2 6/2003 Jacobs
6,584,376 B1 6/2003 Van Kommer
6,590,604 B1 7/2003 Tucker et al.
6,594,269 B1 7/2003 Polcyn
6,597,392 B1 7/2003 Jenkins et al.
6,602,469 B1 8/2003 Maus et al.
6,604,019 B2 8/2003 Ahlin et al.
6,604,021 B2 8/2003 Imai et al.
6,611,120 B2 8/2003 Song et al.
6,643,496 B1 11/2003 Shimoyama et al.
6,646,677 B2 11/2003 Noro et al.
6,650,748 B1 11/2003 Edwards et al.
6,684,129 B2 1/2004 Salisbury et al.
6,691,000 B2 2/2004 Nagai et al.
6,693,585 B1 2/2004 MacLeod
6,710,797 B1 3/2004 McNelley et al.
6,724,823 B2 4/2004 Rovati et al.
6,728,599 B2 4/2004 Wang et al.
6,763,282 B2 7/2004 Glenn et al.
6,764,373 B1 * 7/2004 Osawa et al. 446/175
6,769,771 B2 8/2004 Trumbull
6,781,606 B2 8/2004 Jouppi
6,784,916 B2 8/2004 Smith
6,785,589 B2 8/2004 Eggenberger et al.
6,791,550 B2 9/2004 Goldhor et al.
6,798,753 B1 9/2004 Doganata et al.
6,799,065 B1 9/2004 Niemeyer
6,799,088 B2 9/2004 Wang et al.
6,804,580 B1 10/2004 Stoddard et al.
6,804,656 B1 10/2004 Rosenfeld et al.
6,810,411 B1 10/2004 Coughlin et al.
6,816,192 B1 11/2004 Nishikawa
6,816,754 B2 11/2004 Mukai et al.
6,836,703 B2 12/2004 Wang et al.
6,839,612 B2 1/2005 Sanchez et al.
6,840,904 B2 1/2005 Goldberg
6,845,297 B2 1/2005 Allard
6,852,107 B2 2/2005 Wang et al.
6,853,878 B2 2/2005 Hirayama et al.
6,853,880 B2 2/2005 Sakagami et al.
6,871,117 B2 3/2005 Wang et al.
6,879,879 B2 4/2005 Jouppi et al.
6,888,333 B2 5/2005 Laby
6,892,112 B2 5/2005 Wang et al.
6,893,267 B1 * 5/2005 Yueh 439/8
6,895,305 B2 5/2005 Lathan et al.
6,898,484 B2 * 5/2005 Lemelson et al. 700/245
6,914,622 B1 7/2005 Smith et al.
6,925,357 B2 8/2005 Wang et al.
6,951,535 B2 10/2005 Ghodoussi et al.
6,957,712 B2 10/2005 Song et al.
6,958,706 B2 10/2005 Chaco et al.
6,965,394 B2 11/2005 Gutta et al.
6,990,112 B1 1/2006 Brent et al.
6,995,664 B1 2/2006 Darling
7,007,235 B1 2/2006 Hussein et al.
7,011,538 B2 * 3/2006 Chang 439/172
7,015,934 B2 3/2006 Toyama et al.
RE39,080 E 4/2006 Johnston
7,030,757 B2 4/2006 Matsuhira et al.
7,053,578 B2 * 5/2006 Diehl et al. 318/568.12
7,055,210 B2 * 6/2006 Keppler et al. 15/319
7,058,689 B2 6/2006 Parker et al.
7,092,001 B2 8/2006 Schulz
7,096,090 B1 8/2006 Zweig
7,115,102 B2 10/2006 Abbruscato
7,117,067 B2 10/2006 McLurkin et al.
7,123,285 B2 10/2006 Smith et al.
7,123,974 B1 10/2006 Hamilton
7,123,991 B2 10/2006 Graf et al.
7,127,325 B2 10/2006 Nagata et al.
7,129,970 B2 10/2006 James et al.
7,133,062 B2 11/2006 Castles et al.
7,142,945 B2 11/2006 Wang et al.
7,142,947 B2 11/2006 Wang et al.
7,151,982 B2 12/2006 Liff et al.
7,154,526 B2 12/2006 Foote et al.
7,155,306 B2 12/2006 Haitin et al.
7,156,809 B2 1/2007 Quy
7,158,859 B2 1/2007 Wang et al.
7,158,860 B2 1/2007 Wang et al.
7,158,861 B2 1/2007 Wang et al.
7,161,322 B2 1/2007 Wang et al.
7,162,338 B2 1/2007 Goncalves et al.
7,164,969 B2 1/2007 Wang et al.
7,164,970 B2 1/2007 Wang et al.
7,167,448 B2 1/2007 Wookey et al.
7,171,286 B2 1/2007 Wang et al.
7,174,238 B1 2/2007 Zweig
7,181,455 B2 2/2007 Wookey et al.
7,184,559 B2 2/2007 Jouppi
7,188,000 B2 3/2007 Chiappetta et al.
7,199,790 B2 4/2007 Rosenberg et al.
7,202,851 B2 4/2007 Cunningham et al.
7,206,627 B2 4/2007 Abovitz et al.
7,215,786 B2 5/2007 Nakadai et al.
7,219,364 B2 5/2007 Bolle et al.
7,222,000 B2 5/2007 Wang et al.
7,227,334 B2 * 6/2007 Yang et al. 320/107
7,256,708 B2 8/2007 Rosenfeld
7,262,573 B2 8/2007 Wang et al.
7,283,153 B2 10/2007 Provost et al.
7,289,883 B2 10/2007 Wang et al.
7,292,257 B2 11/2007 Kang et al.
7,305,114 B2 12/2007 Wolff et al.
7,317,685 B1 1/2008 Flott et al.
7,321,807 B2 1/2008 Laski
7,332,890 B2 * 2/2008 Cohen et al. 320/109
7,333,642 B2 2/2008 Green
7,346,429 B2 3/2008 Goldenberg et al.
7,352,153 B2 * 4/2008 Yan 320/107
7,363,121 B1 4/2008 Chen et al.
7,382,399 B1 6/2008 McCall
7,391,432 B2 6/2008 Terada
7,400,578 B2 7/2008 Guthrie et al.
7,404,140 B2 7/2008 O'rourke
7,421,470 B2 9/2008 Ludwig et al.
7,430,209 B2 9/2008 Porter
7,432,949 B2 10/2008 Remy et al.
7,433,921 B2 10/2008 Ludwig et al.
7,441,953 B2 10/2008 Banks
7,492,731 B2 2/2009 Hagendorf
7,510,428 B2 * 3/2009 Obata et al. 439/533
7,523,069 B1 4/2009 Friedl et al.
7,525,281 B2 * 4/2009 Koyanagi et al. 320/107
7,535,486 B2 5/2009 Motomura et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,557,758 B2 7/2009 Rofougaran
7,587,260 B2 9/2009 Bruemmer et al.
7,587,512 B2 9/2009 Ta et al.
7,590,060 B2 9/2009 Miceli
7,599,290 B2 10/2009 Dos Remedios et al.
7,624,166 B2 11/2009 Foote et al.
7,630,314 B2 12/2009 Dos Remedios et al.
7,631,833 B1 12/2009 Ghaleb et al.
7,643,051 B2 1/2010 Sandberg et al.
7,647,320 B2 1/2010 Mok et al.
7,657,560 B1 2/2010 DiRienzo
7,680,038 B1 3/2010 Gourlay
7,693,757 B2 4/2010 Zimmerman
7,698,432 B2 4/2010 Short et al.
7,703,113 B2 4/2010 Dawson
7,719,229 B2 * 5/2010 Kaneko et al. 320/113
7,737,993 B2 6/2010 Kaasila et al.
7,739,383 B1 6/2010 Short et al.
7,756,614 B2 7/2010 Jouppi
7,761,185 B2 7/2010 Wang et al.
7,769,492 B2 8/2010 Wang et al.
7,769,705 B1 8/2010 Luechtefeld
7,774,158 B2 8/2010 Domingues et al.
7,831,575 B2 11/2010 Trossell et al.
7,835,775 B2 11/2010 Sawayama et al.
7,860,680 B2 12/2010 Arms et al.
7,861,366 B2 * 1/2011 Hahm et al. 15/319
7,885,822 B2 2/2011 Akers et al.
7,890,382 B2 2/2011 Robb et al.
7,912,583 B2 3/2011 Gutmann et al.
RE42,288 E 4/2011 Degioanni
7,924,323 B2 4/2011 Walker et al.
7,949,616 B2 5/2011 Levy et al.
7,956,894 B2 6/2011 Akers et al.
7,957,837 B2 6/2011 Ziegler et al.
7,982,763 B2 7/2011 King
7,982,769 B2 7/2011 Jenkins et al.
7,987,069 B2 7/2011 Rodgers et al.
8,126,960 B2 2/2012 Obradovich et al.
8,170,241 B2 5/2012 Roe et al.
8,180,486 B2 5/2012 Saito et al.
8,212,533 B2 * 7/2012 Ota 320/162
8,265,793 B2 9/2012 Cross et al.
8,287,522 B2 10/2012 Moses et al.
8,292,807 B2 10/2012 Perkins et al.
8,320,534 B2 11/2012 Kim et al.
8,340,654 B2 12/2012 Bratton et al.
8,340,819 B2 12/2012 Mangaser et al.
8,348,675 B2 1/2013 Dohrmann
8,374,171 B2 2/2013 Cho et al.
8,400,491 B1 3/2013 Panpaliya et al.
8,401,275 B2 3/2013 Wang et al.
8,423,284 B2 4/2013 O'Shea
8,451,731 B1 5/2013 Lee et al.
8,463,435 B2 6/2013 Herzog et al.
8,503,340 B1 8/2013 Xu
8,515,577 B2 8/2013 Wang et al.
8,527,094 B2 9/2013 Kumar et al.
8,532,860 B2 9/2013 Daly
8,610,786 B2 12/2013 Ortiz
8,639,797 B1 1/2014 Pan et al.
8,670,017 B2 3/2014 Stuart et al.
8,726,454 B2 5/2014 Gilbert, Jr. et al.
8,836,751 B2 9/2014 Ballantyne et al.
8,849,679 B2 9/2014 Wang et al.
8,849,680 B2 9/2014 Wright et al.
8,861,750 B2 10/2014 Roe et al.
8,897,920 B2 11/2014 Wang et al.
8,902,278 B2 12/2014 Pinter et al.
2001/0002448 A1 5/2001 Wilson et al.
2001/0010053 A1 7/2001 Ben-Shachar et al.
2001/0020200 A1 9/2001 Das et al.
2001/0034475 A1 10/2001 Flach et al.
2001/0034544 A1 10/2001 Mo
2001/0037163 A1 11/2001 Allard
2001/0048464 A1 12/2001 Barnett
2001/0051881 A1 12/2001 Filler
2001/0054071 A1 12/2001 Loeb
2001/0055373 A1 12/2001 Yamashita
2002/0015296 A1 2/2002 Howell et al.
2002/0027597 A1 3/2002 Sachau
2002/0027652 A1 3/2002 Paromtchik et al.
2002/0033880 A1 3/2002 Sul et al.
2002/0038168 A1 3/2002 Kasuga et al.
2002/0044201 A1 4/2002 Alexander et al.
2002/0049517 A1 4/2002 Ruffner
2002/0055917 A1 5/2002 Muraca
2002/0057279 A1 5/2002 Jouppi
2002/0058929 A1 5/2002 Green
2002/0059587 A1 5/2002 Cofano et al.
2002/0063726 A1 5/2002 Jouppi
2002/0073429 A1 6/2002 Beane et al.
2002/0082498 A1 6/2002 Wendt et al.
2002/0085030 A1 7/2002 Ghani
2002/0095238 A1 7/2002 Ahlin et al.
2002/0095239 A1 7/2002 Wallach et al.
2002/0098879 A1 7/2002 Rheey
2002/0104094 A1 8/2002 Alexander et al.
2002/0106998 A1 8/2002 Presley et al.
2002/0109770 A1 8/2002 Terada
2002/0109775 A1 8/2002 White et al.
2002/0111988 A1 8/2002 Sato
2002/0120362 A1 8/2002 Lathan et al.
2002/0128985 A1 9/2002 Greenwald
2002/0130950 A1 9/2002 James et al.
2002/0133062 A1 9/2002 Arling et al.
2002/0141595 A1 10/2002 Jouppi
2002/0143923 A1 10/2002 Alexander
2002/0177925 A1 11/2002 Onishi et al.
2002/0183894 A1 12/2002 Wang et al.
2002/0184674 A1 12/2002 Xi et al.
2002/0186243 A1 12/2002 Ellis et al.
2003/0021107 A1 1/2003 Howell et al.
2003/0030397 A1 2/2003 Simmons
2003/0048481 A1 3/2003 Kobayashi
2003/0050733 A1 3/2003 Wang et al.
2003/0050734 A1 3/2003 Lapham
2003/0060808 A1 3/2003 Wilk
2003/0063600 A1 4/2003 Noma et al.
2003/0069752 A1 4/2003 Ledain et al.
2003/0080901 A1 5/2003 Piotrowski
2003/0100892 A1 5/2003 Morley et al.
2003/0104806 A1 6/2003 Ruef et al.
2003/0112823 A1 6/2003 Collins et al.
2003/0114962 A1 6/2003 Niemeyer
2003/0120714 A1 6/2003 Wolff et al.
2003/0126361 A1 7/2003 Slater et al.
2003/0135097 A1 7/2003 Wiederhold et al.
2003/0135203 A1 7/2003 Wang et al.
2003/0144579 A1 7/2003 Buss
2003/0144649 A1 7/2003 Ghodoussi et al.
2003/0151658 A1 8/2003 Smith
2003/0152145 A1 8/2003 Kawakita
2003/0171710 A1 9/2003 Bassuk et al.
2003/0174285 A1 9/2003 Trumbull
2003/0180697 A1 9/2003 Kim et al.
2003/0195662 A1 10/2003 Wang et al.
2003/0199000 A1 10/2003 Valkirs et al.
2003/0206242 A1 11/2003 Choi et al.
2003/0212472 A1 11/2003 McKee
2003/0216833 A1 11/2003 Mukai et al.
2003/0216834 A1 11/2003 Allard
2003/0220541 A1 11/2003 Salisbury et al.
2003/0220715 A1 11/2003 Kneifel, II et al.
2003/0231244 A1 12/2003 Bonilla et al.
2003/0232649 A1 12/2003 Gizis
2003/0236590 A1 12/2003 Park et al.
2004/0001197 A1 1/2004 Ko et al.
2004/0001676 A1 1/2004 Colgan et al.
2004/0008138 A1 1/2004 Hockley, Jr. et al.
2004/0010344 A1 1/2004 Hiratsuka
2004/0012362 A1 1/2004 Tsurumi
2004/0013295 A1 1/2004 Sabe et al.
2004/0017475 A1 1/2004 Akers et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2004/0019406	A1*	1/2004	Wang et al.	700/231
2004/0024490	A1	2/2004	McLurkin et al.	
2004/0041904	A1	3/2004	Lapalme et al.	
2004/0065073	A1	4/2004	Nash	
2004/0068657	A1	4/2004	Alexander et al.	
2004/0078219	A1	4/2004	Kaylor et al.	
2004/0080610	A1	4/2004	James et al.	
2004/0088077	A1	5/2004	Jouppi et al.	
2004/0088078	A1	5/2004	Jouppi et al.	
2004/0093409	A1	5/2004	Thompson et al.	
2004/0095516	A1	5/2004	Rohlicek	
2004/0098167	A1	5/2004	Yi et al.	
2004/0102167	A1	5/2004	Shim et al.	
2004/0107254	A1	6/2004	Ludwig et al.	
2004/0107255	A1	6/2004	Ludwig et al.	
2004/0117065	A1	6/2004	Wang et al.	
2004/0117067	A1	6/2004	Jouppi	
2004/0123158	A1	6/2004	Roskind	
2004/0135879	A1	7/2004	Stacy et al.	
2004/0138547	A1	7/2004	Wang et al.	
2004/0143421	A1	7/2004	Wang et al.	
2004/0148638	A1	7/2004	Weisman et al.	
2004/0150725	A1	8/2004	Taguchi	
2004/0153211	A1	8/2004	Kamoto et al.	
2004/0157612	A1	8/2004	Kim	
2004/0162637	A1	8/2004	Wang et al.	
2004/0167666	A1	8/2004	Wang et al.	
2004/0167668	A1	8/2004	Wang et al.	
2004/0168148	A1	8/2004	Goncalves et al.	
2004/0170300	A1	9/2004	Jouppi	
2004/0172301	A1	9/2004	Mihai et al.	
2004/0172306	A1	9/2004	Wohl et al.	
2004/0174129	A1	9/2004	Wang et al.	
2004/0175684	A1	9/2004	Kaasa et al.	
2004/0179714	A1	9/2004	Jouppi	
2004/0186623	A1	9/2004	Dooley et al.	
2004/0189700	A1	9/2004	Mandavilli et al.	
2004/0201602	A1	10/2004	Mody et al.	
2004/0205664	A1	10/2004	Prendergast	
2004/0215490	A1	10/2004	Duchon et al.	
2004/0218099	A1	11/2004	Washington	
2004/0222638	A1	11/2004	Bednyak	
2004/0224676	A1	11/2004	Iseki	
2004/0230340	A1	11/2004	Fukuchi et al.	
2004/0240981	A1	12/2004	Dothan et al.	
2004/0241981	A1	12/2004	Doris et al.	
2005/0003330	A1	1/2005	Asgarinejad	
2005/0004708	A1	1/2005	Goldenberg et al.	
2005/0007445	A1	1/2005	Foote et al.	
2005/0013149	A1	1/2005	Trossell	
2005/0021182	A1	1/2005	Wang et al.	
2005/0021183	A1	1/2005	Wang et al.	
2005/0021187	A1	1/2005	Wang et al.	
2005/0021309	A1	1/2005	Alexander et al.	
2005/0024485	A1	2/2005	Castles et al.	
2005/0027567	A1	2/2005	Taha	
2005/0027794	A1	2/2005	Decker	
2005/0028221	A1	2/2005	Liu et al.	
2005/0035862	A1	2/2005	Wildman et al.	
2005/0038416	A1	2/2005	Wang et al.	
2005/0038564	A1	2/2005	Burick	
2005/0049898	A1	3/2005	Hirakawa	
2005/0052527	A1	3/2005	Remy et al.	
2005/0060211	A1	3/2005	Xiao et al.	
2005/0065435	A1	3/2005	Rauch et al.	
2005/0065438	A1	3/2005	Miller	
2005/0065659	A1	3/2005	Tanaka et al.	
2005/0065813	A1	3/2005	Mishelevich et al.	
2005/0071046	A1	3/2005	Miyazaki et al.	
2005/0073575	A1	4/2005	Thacher et al.	
2005/0078816	A1	4/2005	Sekiguchi et al.	
2005/0083011	A1*	4/2005	Yang et al.	320/107
2005/0099493	A1	5/2005	Chew	
2005/0104964	A1	5/2005	Bovyrin et al.	
2005/0110867	A1	5/2005	Schultz	
2005/0122390	A1	6/2005	Wang et al.	
2005/0125083	A1	6/2005	Kiko	
2005/0125098	A1	6/2005	Wang et al.	
2005/0149364	A1	7/2005	Ombrellaro	
2005/0152447	A1	7/2005	Jouppi et al.	
2005/0152565	A1	7/2005	Jouppi et al.	
2005/0154265	A1	7/2005	Miro et al.	
2005/0168568	A1	8/2005	Jouppi	
2005/0182322	A1	8/2005	Grispo	
2005/0192721	A1	9/2005	Jouppi	
2005/0204438	A1	9/2005	Wang et al.	
2005/0212478	A1*	9/2005	Takenaka	320/107
2005/0219356	A1	10/2005	Smith et al.	
2005/0225634	A1	10/2005	Brunetti et al.	
2005/0231156	A1*	10/2005	Yan	320/107
2005/0231586	A1	10/2005	Rodman et al.	
2005/0232647	A1*	10/2005	Takenaka	399/27
2005/0234592	A1	10/2005	McGee et al.	
2005/0264649	A1	12/2005	Chang et al.	
2005/0267826	A1	12/2005	Levy et al.	
2005/0283414	A1	12/2005	Fernandes et al.	
2005/0286759	A1	12/2005	Zitnick et al.	
2006/0007943	A1	1/2006	Fellman	
2006/0010028	A1	1/2006	Sorensen	
2006/0013263	A1	1/2006	Fellman	
2006/0013469	A1*	1/2006	Wang et al.	382/153
2006/0013488	A1	1/2006	Inoue	
2006/0014388	A1	1/2006	Lur et al.	
2006/0020694	A1	1/2006	Nag et al.	
2006/0029065	A1	2/2006	Fellman	
2006/0047365	A1	3/2006	Ghodoussi et al.	
2006/0048286	A1	3/2006	Donato	
2006/0052676	A1	3/2006	Wang et al.	
2006/0052684	A1	3/2006	Takahashi et al.	
2006/0056655	A1	3/2006	Wen et al.	
2006/0056837	A1	3/2006	Vapaakoski	
2006/0064212	A1	3/2006	Thorne	
2006/0066609	A1	3/2006	Iodice et al.	
2006/0071797	A1	4/2006	Rosenfeld et al.	
2006/0074525	A1	4/2006	Close et al.	
2006/0074719	A1	4/2006	Horner	
2006/0082642	A1	4/2006	Wang et al.	
2006/0087746	A1	4/2006	Lipow	
2006/0095158	A1	5/2006	Lee et al.	
2006/0095170	A1	5/2006	Yang et al.	
2006/0098573	A1	5/2006	Beer et al.	
2006/0103659	A1	5/2006	Karandikar et al.	
2006/0104279	A1	5/2006	Fellman et al.	
2006/0106493	A1	5/2006	Niemeyer et al.	
2006/0122482	A1	6/2006	Mariotti et al.	
2006/0125356	A1	6/2006	Meek, Jr. et al.	
2006/0142983	A1	6/2006	Sorensen	
2006/0149418	A1	7/2006	Anvari	
2006/0161136	A1	7/2006	Anderson et al.	
2006/0161303	A1	7/2006	Wang et al.	
2006/0164546	A1	7/2006	Adachi et al.	
2006/0171515	A1	8/2006	Hintermeister et al.	
2006/0173708	A1	8/2006	Vining et al.	
2006/0173712	A1	8/2006	Joubert	
2006/0178559	A1	8/2006	Kumar et al.	
2006/0178776	A1	8/2006	Feingold et al.	
2006/0178777	A1	8/2006	Park et al.	
2006/0189393	A1	8/2006	Edery	
2006/0195569	A1	8/2006	Barker	
2006/0224781	A1	10/2006	Tsao et al.	
2006/0247045	A1	11/2006	Jeong et al.	
2006/0259193	A1	11/2006	Wang et al.	
2006/0268704	A1	11/2006	Ansari et al.	
2006/0271238	A1	11/2006	Choi et al.	
2006/0271400	A1	11/2006	Clements et al.	
2006/0293788	A1	12/2006	Pogodin	
2007/0021871	A1	1/2007	Wang et al.	
2007/0025711	A1	2/2007	Marcus	
2007/0046237	A1	3/2007	Lakshmanan et al.	
2007/0050937	A1*	3/2007	Song et al.	15/319
2007/0064092	A1	3/2007	Sandberg et al.	
2007/0078566	A1*	4/2007	Wang et al.	700/259
2007/0093279	A1*	4/2007	Janik	455/569.1
2007/0112700	A1	5/2007	Den et al.	

(56) **References Cited**

U.S. PATENT DOCUMENTS

2007/0116152	A1	5/2007	Thesling	
2007/0117516	A1	5/2007	Saidi et al.	
2007/0120965	A1	5/2007	Sandberg et al.	
2007/0122783	A1	5/2007	Habashi	
2007/0133407	A1	6/2007	Choi et al.	
2007/0135967	A1	6/2007	Jung et al.	
2007/0142964	A1	6/2007	Abramson	
2007/0170886	A1*	7/2007	Plishner	320/104
2007/0176060	A1	8/2007	White et al.	
2007/0192910	A1	8/2007	Vu et al.	
2007/0197896	A1	8/2007	Moll et al.	
2007/0198128	A1	8/2007	Ziegler et al.	
2007/0198130	A1	8/2007	Wang et al.	
2007/0199108	A1	8/2007	Angle et al.	
2007/0216347	A1*	9/2007	Kaneko et al.	320/107
2007/0226949	A1*	10/2007	Hahm et al.	15/340.1
2007/0250212	A1	10/2007	Halloran et al.	
2007/0255706	A1	11/2007	Iketani et al.	
2007/0262884	A1	11/2007	Goncalves et al.	
2007/0273751	A1	11/2007	Sachau	
2007/0290040	A1*	12/2007	Wurman et al.	235/385
2007/0291109	A1	12/2007	Wang et al.	
2007/0291128	A1	12/2007	Wang et al.	
2008/0009969	A1	1/2008	Bruemmer et al.	
2008/0011904	A1	1/2008	Cepollina et al.	
2008/0027591	A1	1/2008	Lenser et al.	
2008/0033641	A1	2/2008	Medalia	
2008/0045804	A1	2/2008	Williams	
2008/0051985	A1*	2/2008	D'Andrea et al.	701/200
2008/0065268	A1	3/2008	Wang et al.	
2008/0082211	A1	4/2008	Wang et al.	
2008/0086241	A1	4/2008	Phillips et al.	
2008/0091340	A1	4/2008	Milstein et al.	
2008/0126132	A1	5/2008	Warner et al.	
2008/0133052	A1*	6/2008	Jones et al.	700/245
2008/0161969	A1*	7/2008	Lee et al.	700/245
2008/0174570	A1	7/2008	Jobs et al.	
2008/0201016	A1	8/2008	Finlay	
2008/0201017	A1	8/2008	Wang et al.	
2008/0215987	A1	9/2008	Alexander et al.	
2008/0229531	A1	9/2008	Takida	
2008/0232763	A1	9/2008	Brady	
2008/0255703	A1	10/2008	Wang et al.	
2008/0263451	A1	10/2008	Portele et al.	
2008/0267069	A1	10/2008	Thielman et al.	
2008/0269949	A1	10/2008	Norman et al.	
2008/0281467	A1	11/2008	Pinter	
2008/0306375	A1	12/2008	Sayler et al.	
2009/0030552	A1	1/2009	Nakadai et al.	
2009/0044334	A1	2/2009	Parsell et al.	
2009/0049640	A1*	2/2009	Lee et al.	15/319
2009/0055023	A1	2/2009	Walters et al.	
2009/0070135	A1	3/2009	Parida et al.	
2009/0086013	A1	4/2009	Thapa	
2009/0102919	A1	4/2009	Zamierowski et al.	
2009/0105882	A1	4/2009	Wang et al.	
2009/0106679	A1	4/2009	Anzures et al.	
2009/0122699	A1	5/2009	Alperovitch et al.	
2009/0125147	A1	5/2009	Wang et al.	
2009/0144425	A1	6/2009	Marr et al.	
2009/0164255	A1	6/2009	Menschik et al.	
2009/0164657	A1	6/2009	Li et al.	
2009/0171170	A1	7/2009	Li et al.	
2009/0177323	A1	7/2009	Ziegler et al.	
2009/0177641	A1	7/2009	Raghavan	
2009/0237317	A1	9/2009	Rofougaran	
2009/0240371	A1	9/2009	Wang et al.	
2009/0248200	A1	10/2009	Root	
2009/0259339	A1	10/2009	Wright et al.	
2010/0010672	A1*	1/2010	Wang et al.	700/259
2010/0010673	A1	1/2010	Wang et al.	
2010/0017046	A1	1/2010	Cheung et al.	
2010/0019715	A1	1/2010	Roe et al.	
2010/0026239	A1*	2/2010	Li et al.	320/109
2010/0030578	A1	2/2010	Siddique et al.	
2010/0051596	A1	3/2010	Diedrick et al.	
2010/0063848	A1	3/2010	Kremer et al.	
2010/0066804	A1	3/2010	Shoemake et al.	
2010/0070079	A1	3/2010	Mangaser et al.	
2010/0073490	A1	3/2010	Wang et al.	
2010/0076600	A1*	3/2010	Cross et al.	700/259
2010/0085874	A1	4/2010	Noy et al.	
2010/0088232	A1	4/2010	Gale	
2010/0115418	A1	5/2010	Wang et al.	
2010/0116566	A1	5/2010	Ohm et al.	
2010/0131103	A1	5/2010	Herzog et al.	
2010/0145479	A1	6/2010	Griffiths	
2010/0157825	A1	6/2010	Anderlind et al.	
2010/0171826	A1	7/2010	Hamilton et al.	
2010/0191375	A1	7/2010	Wright et al.	
2010/0228249	A1	9/2010	Mohr et al.	
2010/0268383	A1	10/2010	Wang et al.	
2010/0278086	A1	11/2010	Pochiraju et al.	
2010/0286905	A1	11/2010	Goncalves et al.	
2010/0301679	A1*	12/2010	Murray et al.	307/116
2010/0323783	A1	12/2010	Nonaka et al.	
2011/0022705	A1	1/2011	Yellamraju et al.	
2011/0050841	A1	3/2011	Wang et al.	
2011/0071675	A1	3/2011	Wells et al.	
2011/0071702	A1	3/2011	Wang et al.	
2011/0072114	A1	3/2011	Hoffert et al.	
2011/0153198	A1	6/2011	Kokkas et al.	
2011/0172822	A1	7/2011	Ziegler et al.	
2011/0187875	A1	8/2011	Sanchez et al.	
2011/0190930	A1	8/2011	Hanrahan et al.	
2011/0193949	A1	8/2011	Nambakam et al.	
2011/0195701	A1	8/2011	Cook et al.	
2011/0213210	A1	9/2011	Temby et al.	
2011/0218674	A1	9/2011	Stuart et al.	
2011/0245973	A1	10/2011	Wang et al.	
2011/0280551	A1	11/2011	Sammon	
2011/0292193	A1	12/2011	Wang et al.	
2011/0301759	A1	12/2011	Wang et al.	
2011/0306400	A1	12/2011	Nguyen	
2012/0023506	A1	1/2012	Maeckel et al.	
2012/0036484	A1	2/2012	Zhang et al.	
2012/0059946	A1	3/2012	Wang	
2012/0072023	A1	3/2012	Ota	
2012/0072024	A1	3/2012	Wang et al.	
2012/0092157	A1	4/2012	Tran	
2012/0095352	A1	4/2012	Tran	
2012/0113856	A1	5/2012	Krishnaswamy	
2012/0191246	A1	7/2012	Roe et al.	
2012/0191464	A1	7/2012	Stuart et al.	
2012/0203731	A1	8/2012	Nelson et al.	
2012/0242279	A1*	9/2012	Tso et al.	320/107
2012/0291809	A1*	11/2012	Kuhe et al.	134/18
2013/0250938	A1	9/2013	Anandakumar et al.	
2014/0047022	A1	2/2014	Chan et al.	
2014/0085543	A1	3/2014	Hartley et al.	
2014/0135990	A1	5/2014	Stuart et al.	
2014/0139616	A1	5/2014	Pinter et al.	
2014/0155755	A1	6/2014	Pinter et al.	
2015/0119652	A1*	4/2015	Hyde et al.	600/301

FOREIGN PATENT DOCUMENTS

CN	1404695	A	3/2003
CN	1554193	A	12/2004
CN	1554985	A	12/2004
CN	1561923	A	1/2005
CN	1743144	A	3/2006
CN	101049017	A	10/2007
CN	101106939	A	1/2008
CN	101151614	A	3/2008
CN	100407729	C	7/2008
CN	101390098	A	3/2009
CN	101507260	A	8/2009
CN	101730894	A	6/2010
CN	101866396	A	10/2010
CN	101978365	A	2/2011
CN	102203759	A	9/2011
CN	101106939	B	11/2011
EP	92/466492		1/1992

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

EP	92/488673	A2	6/1992
EP	0981905	B1	1/2002
EP	1 262 142	A2	12/2002
EP	1304872	A1	4/2003
EP	1 536 660	B2	9/2004
EP	1 536 660	A2	6/2005
EP	2005/1573406	A2	9/2005
EP	2005/1594660	A2	11/2005
EP	1763243	A2	3/2007
EP	2007/1791464	A2	6/2007
EP	2007/1800476	A2	6/2007
EP	1819108	A2	8/2007
EP	2007/1856644	A2	11/2007
EP	2008/1928310	A2	6/2008
EP	1232610	B1	1/2009
EP	2009/2027716	A2	2/2009
EP	2010/2145274	A1	1/2010
EP	2010/2214111	A2	8/2010
EP	2010/2263158	A2	12/2010
EP	2011/2300930	A2	3/2011
EP	2011/2342651	A2	7/2011
GB	2431261	A	4/2007
JP	07-194609	A	8/1995
JP	2007-213753	A	8/1995
JP	2007-248823	A	8/1995
JP	07-257422	A	10/1995
JP	08-084328	A	3/1996
JP	96/8320727	A	12/1996
JP	9-267276	A	10/1997
JP	10079097	A	3/1998
JP	10288689	A	10/1998
JP	11-220706	A	8/1999
JP	11220706	A	8/1999
JP	2000-032319	A	1/2000
JP	2000/049800	A	2/2000
JP	2000/079587	A	3/2000
JP	2000/196876	A	7/2000
JP	2000-235423	A	8/2000
JP	2001/125641	A	5/2001
JP	2001-147718	A	5/2001
JP	2001/179663	A	7/2001
JP	2001-198865	A	7/2001
JP	2001-198868	A	7/2001
JP	2001-199356	A	7/2001
JP	2000-188124		1/2002
JP	2002-000574	A	1/2002
JP	2002-046088	A	2/2002
JP	2002/112970	A	4/2002
JP	2002/101333	A	5/2002
JP	2002-305743	A	10/2002
JP	2002-321180	A	11/2002
JP	2002-355779	A	12/2002
JP	2004-181229	A	7/2004
JP	2004/524824	T	8/2004
JP	2004/261941	A	9/2004
JP	2004/289379	A	10/2004
JP	2005/028066	A	2/2005
JP	2005/059170	A	3/2005
JP	2005-111083	A	4/2005
JP	2006/508806	A	3/2006
JP	2006/109094	A	4/2006
JP	2006/224294	A	8/2006
JP	2006/246438	A	9/2006
JP	2007-7040	A	1/2007
JP	2007/081646	A	3/2007
JP	2007-232208	A	9/2007
JP	2007-316966	A	12/2007
JP	2009-125133	A	6/2009
JP	2010/064154	A	3/2010
JP	2010/532109	A	9/2010
JP	2010/246954	A	11/2010
KR	2006/0037979	A	5/2006
KR	2009/0012542	A	2/2009
KR	2010/0019479	A	2/2010
KR	2010/0139037	A	12/2010
WO	WO 93/06690	A1	4/1993
WO	97/42761	A1	11/1997
WO	WO 98/51078	A	11/1998
WO	WO 99/67067	A1	12/1999
WO	00/25516	A1	5/2000
WO	00/33726	A3	6/2000
WO	01/31861	A1	5/2001
WO	WO 03/077745	A	9/2003
WO	2004/008738	A1	1/2004
WO	2004/012018	A2	2/2004
WO	WO 2004/075456	A2	9/2004
WO	2006/012797	A1	2/2006
WO	2006/044847	A2	4/2006
WO	2006/078611	A1	4/2006
WO	2007/041295	A2	4/2007
WO	WO 2007/041295		4/2007
WO	2007/041038	A1	6/2007
WO	2008/100272	A2	8/2008
WO	2008/100272	A3	10/2008
WO	2009/117274	A2	9/2009
WO	2009/128997	A1	10/2009
WO	2009/145958	A2	12/2009
WO	2010/006205	A1	1/2010
WO	2010/006211	A1	1/2010
WO	2010/033666	A1	3/2010
WO	2010/047881	A1	4/2010
WO	2010/062798	A1	6/2010
WO	2010/065257	A1	6/2010
WO	2010/120407	A1	10/2010
WO	2011/028589	A2	3/2011
WO	2011/028589	A3	4/2011
WO	2011/097130	A2	8/2011
WO	2011/097132	A2	8/2011
WO	2011/109336	A2	9/2011
WO	2011/097132	A3	12/2011
WO	2011/149902	A2	12/2011

OTHER PUBLICATIONS

Baltus et al., "Towards Personal Service Robots for the Elderly", Computer Science and Robotoics.

Bar-Cohen et al., Virtual reality robotic telesurgery simulations using MEMICA haptic system, Mar. 5, 2001, Internet, pp. 1-7.

Bauer, Jeffrey C., "Service Robots in Health Care: The Evolution of Mechanical Solutions to Human Resource Problems", Jun. 2003.

Bauer, John et al., "Remote telesurgical mentoring: feasibility and efficacy", 2000, IEEE, pp. 1-9.

Breslow, Michael J., MD et al., "Effect of a multiple-site intensive care unit telemedicine program on clinical and economic outcome: An alternative paradigm for intensivist staffing", Critical Care Med, Jan. 2004, vol. 32, No. 1, pp. 31-38.

Brooks, Rodney, Abstracts from Flesh & Machines, How Robots Will Change Us, "Remote Presence", p. 131-147, Feb. 2002.

Celi et al., "The eICU: It's not just telemedicine", Critical Care Medicine, vol. 29, No. 8 (Supplement), Aug. 2001.

Cleary et al., "State of the art in surgical robotics: Clinical applications and technology challenges", Feb. 24, 2002 Internet, pp. 1-26.

CNN, Floating 'droids' to roam space corridors of the future, Jan. 12, 2000, Internet, pp. 1-4.

CNN.com/Technology, Paging R.Robot: Machine helps doctors with patients, Sep. 30, 2003, Internet, 1-3.

Davies, "Robotics in Minimally Invasive Surgery", 1995, Internet, pp. 5/1-5/2.

DiGiorgio, James, "Is Your Emergency Department of the 'Leading Edge'?", 2005, Internet, pp. 1-4.

Elhajj et al., "Supermedia in Internet-based telerobotic operations", 2001, Internet, pp. 1-14.

Ellison et al., "Telerounding and Patient Satisfaction Following Surgery".

Fetterman, Videoconferencing over the Internet, 2001, Internet, pp. 1-8.

Goldberg et al., "Collaborative Teleoperation via the Internet", IEEE International Conference on Robotics and Automation, Apr. 2000, San Francisco, California.

Goldman, Lea, "Machine Dreams", Entrepreneurs, Forbes, May 27, 2002.

(56) **References Cited**

OTHER PUBLICATIONS

Gump, Michael D., "Robot Technology Improves VA Pharmacies", 2001, Internet, pp. 1-3.
Harmo et al., "Moving Eye—Interactive Telepresence Over Internet With a Ball Shaped Mobile Robot", 2000.
Hees, William P., "Communications Design for a Remote Presence Robot", Jan. 14, 2002.
F.A. Candelas Herias et al., "Flexible virtual and remote laboratory for teaching Robotics", Formatex 2006, Proc. Advance in Control Education, Madrid, Spain, Jun. 21-23, 2006.
Ishihara, Ken et al., "Intelligent Microrobot DDS (Drug Delivery System) Measured and Controlled by Ultrasonics", Nov. 3-5, 1991, IEEE/RSJ, pp. 1145-1150, vol. 2.
Ivanova, Natali, "Master's thesis: Internet Based Interface for Control of a Mobile Robot", Department of Numerical Analysis and Computer Science.
Johanson, Supporting video-mediated communication over the Internet, Chalmers University of Technology, Dept of Computer Engineering, Gothenburg, Sweden, 2003.
Jouppi, et al., :Mutually-Immersive Audio Telepresence, Audio Engineering Society Convention Paper, presented at 113th Convention Oct. 2002.
Jouppi, Norman P., "First Steps Towards Mutually-Immersive Mobile Telepresence", CSCW '02, Nov. 16-20, 2002, New Orleans LA.
Kanehiro, Fumio et al., Virtual Humanoid Robot Platform to Develop Controllers of Real Humanoid Robots without Porting, 2001, IEEE, pp. 3217-3276.
Kaplan et al., "An Internet Accessible Telepresence".
Kuzuoka et al., "Can the GestureCam Be a Surrogate?".
Lim, Hun-ok et al., Control to Realize Human-like Walking of a Biped Humanoid Robot, IEEE 2000, pp. 3271-3276.
Linebarger, John M. et al., "Concurrency Control Mechanisms for Closely Coupled Collaboration in Multithreaded Virtual Environments", Presence, Special Issue on Advances in Collaborative VEs (2004).
Loeb, Gerald, "Virtual Visit: Improving Communication for Those Who Need It Most", 2001.
Mack, "Minimally invasive and robotic surgery", 2001, Internet IEEE, pp. 568-572.
Martin, Anya, "Days Ahead", Assisted Living Today, vol. 9, Nov./Dec. 2002, pp. 19-22.
McCardle et al., "The challenge of utilizing new technology in design education", 2000 Internet, pp. 122-127.
"More Online Robots, Robots that Manipulate", Internet, http://ford.ieor.berkeley.edu/ir/robots_a2.html, Feb. 2007.
Nakajima et al., "A Multimedia Teleteaching System sing an Electronic Whiteboard for Two-Way Communication of Motion Videos and Chalkboards", 1993, IEEE, pp. 436-441.
Ogata et al., "Development of Emotional Communication Robot: WAMOEBA-2r—Esperimental evaluation . . . ", 2000 IEEE, pp. 175-180.
Ojha, Anad, "An application of Virtual Reality in Rehabilitation", Jan. 1994, IEEE, pp. 4-6.
Paulos et al., "A World Wide Web Telerobotic Remote Environment Browser", http://vive.cs.berkeley.edu/capek, 1995.
Paulos, Eric John, "Personal Tele-Embodiment", Fall 2001.
Paulos, et al. , "Ubiquitous Tele-embodiment: Applications and Implications", International Journal of Human Computer Studies, Jun. 1997, vol. 46, No. 6, pp. 861-877.
Pin et al., "A New Family of Omnidirectional and Holonomic Wheeled Platforms for Mobile Robots", IEEE, vol. 10, No. 4, Aug. 1994.
Robot Hardware Mobile Robotics Research Group, Edinburgh, "Mobile Robotics Research Group", 2000 Internet, pp. 1-2.
Roy et al., "Towards Personal Service Robots for the Elderly", Internet, Mar. 7, 2002.
Salemi et al, "MILO: Personal robot platform", 2005, Internet, pp. 1-6.
Sandt, Frederic et al., "Perceptions for a Transport Robot in Public Environments", 1997, IROS '97.
Shimoga et al., Touch and force reflection for telepresence surgery, 1994, IEEE, pp. 1049-1050.
Stephenson, Gary, "Dr. Robot Tested at Hopkins", Aug. 5, 2003, Internet, pp. 1-2.
Stoianovici et al., "Robotic Tools for Minimally Invasive Urologic Surgery", Dec. 2002, Internet, 1-17.
Tendick et al., "Human-Machine Interfaces for Minimally Invasive Surgery", 1997, IEEE, pp. 2771-2776.
Thrun et al, "Probabilistic Algorithms and the Interactive Museum Tour-Guide Robot Minerva", 2000, Internet pp. 1-35.
Tzafestas, et al., "VR-based Teleoperation of a Mobile Robotic Assistant: Progress Report", 2000, Internet, pp. 1-23.
Urquhart, Kim, "InTouch's robotic Companion 'beams up' healthcare experts", Medical Device Daily, vol. 7, No. 39, Feb. 27, 2003, p. 1, 4.
Weiss et al., Telework and video-mediated communication: Importance of real-time, interactive communication for workers with disabilities, 1999, Internet, pp. 1-4.
Yamasaki et al., Applying Personal Robots and Active Interface to Video Conference Systems, 1995, Internet, pp. 243-248.
Yong et al., "Robot task execution with telepresence using virtual reality technology", 1998, Internet, pp. 1-9.
Zipperer, Lorri, "Robotic dispensing system", 1999, Internet, pp. 1-2.
Zorn, Benjamin G., "Ubiquitous Telepresence", http://www.cs.colorado.edu/~zorn/ut/vision/vision.html, Mar. 5, 1996.
Al-Kassab, "A Review of Telemedicine", Journal of Telemedicine and Telecare, 1999, vol. 5, Supplement 1.
Android Amusement Corp., "What Marketing Secret", 1982 http:///www.theoldrobots.com/images17/dc8.jpg.
Applebome, "Planning Domesticated Robots for Tomorrow's Household", New York Times, Mar. 4, 1982, pp. 21 and 23 http://www.theoldrobots.com/images17/dc17.jpg.
Bartholomew, "An Apothecary's Pharmacy", 1230-1240 http://classes.bnf.fr/ema/grands/034.htm.
Bischoff, "Design Concept and Realization of the Humanoid Service Robot HERMES", Field and Service Robotics, Springer, London, 1998, pp. 485-492.
Blackwell, Gerry, "Video: A Wireless LAN Killer App?", 2002, Internet pp. 1-3.
Cheetham, Anastasia et al., "Interface Development for a Child's Video Conferencing Robot", 2000, pp. 1-4.
Crowley, "Hello to Our Future", AARP Bulletin, Jan. 2000 http://www.cs.cmu.ed/-nursebot/web/press/aarp_99_14/millennium.html.
Dalton, "Techniques for Web Telerobotics", PhD Thesis, University of Western Australia, 2001, pp. 27-62, 149-191; http://telerobot.mech.uwa.edu.au/information.html, http://catalogue.library.uwa.edu.au/search.
Discovery Channel Canada, "Inventing the Future: 2000 Years of Discovery", Jan. 2, 2000 (Video/Transcript).
Elhajj et al., "Synchronization and Control of Supermedia Transmission Via the Internet", Proceedings of 2001 International Symposium on Intelligent Multimedia, Video and Speech Processing, May 2-4, 2001, Hong Kong.
Fels, "Developing a Video-Mediated Communication System for Hospitalized Children", Telemedicine Journal, vol. 5, No. 2, 1999.
Fiorini, "Health Care Robotics: A Progress Report", IEEE International Conference on Robotics and Automation, 1997.
Ghiasi, "A Generic Web-based Teleoperations Architecture: Details and Experience", SPIE Conference on Telemanipulator and Telepresence Technologies VI, Sep. 1999.
Goldberg, "Desktop Teleoperation via the World Wide Web, Proceedings of the IEEE International Conference on Robotics and Automation", 1995, pp. 654-659 http://citeseer.ist.psu.edu/cache/papers/cs/5/ftp:zSzzSzusc.eduzSzpubzSziriszSzraiders.pdf/gol.
Goldberg, "More Online Robots, Robots that Manipulate", Internet, Updated Aug. 2001 http://ford.ieor.berkeley.edu/ir/robots_a2.html.
Handley, "RFC 2327—SDP: Session Description Protocol", Apr. 1998 http://www.faqs.org/rfcs/rfc2327.html.

(56) **References Cited**

OTHER PUBLICATIONS

Hanebeck, "Roman: a mobile Robotic Assistant for Indoor Service Applications", Proceedings of the 1997 IEEE/RSJ International Conference on Intelligent Robots and Systems, 1997.
Haule et al., "Control Scheme for Delayed Teleoperation Tasks", May 17, 1995, Proceedings of the Pacific Rim Conference on Communications, Computer and Signal Processing.
Holmberg, "Development of a Holonomic Mobile Robot for Mobile Manipulation Tasks", International Conference on Field and Service Robotics, Pittsburgh, PA, Aug. 1999.
Ishiguro, "Integrating a Perceptual Information Infrastructure with Robotic Avatars: A Framework for Tele-Existence" Proceeding of IEEE Conference on Intelligent Robots and Systems, http://www.ai.soc.i.kyoto-u.ac.jp/services/publications/99/99conf/07.pdf.
Itu, "ITU-T H.323 Packet-based multimedia communications", ITU, Feb. 1998, http://www.itu.int/rec/T-REC-H.323-199802-S/en.
Jenkins, "Telehealth Advancing Nursing Practice", Nursing Outlook, Mar./Apr. 2001, vol. 49, No. 2.
Keller et al., "Raven Interface Project", Fall 2001 http://upclose.lrdc.pitt.edu/people/louw_assets/Raven_Slides.pps.
Khatib, "Robots in Human Environments", Proc. International Conference on Control, Automation, Robotics, and Vision, ICRACV2000, Dec. 2000, Singapore, pp. 454-457.
Lane, "Automated Aides", Newsday, Oct. 17, 2000, http://www.cs.cum.edu/-nursebot/web/press/nd4380.htm.
Lee et al., "A novel method of surgical instruction: International telementoring", 1998, Internet pp. 1-4.
Long, "HelpMate Robotics, Inc. (Formerly Transitions Research Corporation) Robot Navigation Technology", NIST Special Publication 950-1, Mar. 1999, http://www.atp.nist.gov/eao/sp950-1/helpmate.htm.
Luna, Nancy, "Robot a new face on geriatric care", OC Register, Aug. 6, 2003.
Mair, "Telepresence—The Technology and Its Economic and Social Implications", IEEE Technology and Society, 1997.
Meng et al., "E-Service Robot in Home Healthcare", Proceedings of the 2000 IEEE/RSJ, International Conference on Intelligent Robots and Systems, 2000, pp. 832-837.
Michaud, "Introducing 'Nursebot'", The Boston Globe, Sep. 11, 2001, pp. 1-5, http://www.cs.cmu.edu/nursebot/web/press/globe_3_01/index.html.
Mobile Robotics Research Group, "Mobile Robotics Research Group", 2000 Internet, pp. 1-2, Edinburgh.
Montemerlo, "Telepresence: Experiments in Next Generation Internet", CMU Robotics Institute, Oct. 20, 1998, http://www.ri.cmu.edu/creative/archives.htm (Video/Transcript).
Murphy, "Introduction to A1 Robotics", 2000.
"National Energy Research Scientific Computing Center, Berkeley Lab's Rage Telepresence Robot Captures R&D100 Award", Jul. 2, 2002, http://www.nersc.gov/news/newsroom/RAGE070202.php.
Nomadic Technologies, Inc., "Nomad XR4000 Hardware Manual", Mar. 1999.
Ogata et al., "Emotional Communication Robot: WAMOEBA-2R—Emotion Model and Evaluation Experiments", 1999, Internet, pp. 1-16.
Oh et al., "Autonomous Battery Recharging for Indoor Mobile Robots", Proceedings of Australian Conference on Robotics and Automation, 2000, http://users.rsise.anu.edu.au/rsl/rsl_papers/ACRA2000/Auto_Recharge_Paper.pdf.
Paulos, "Designing Personal Tele-embodiment", IEEE International Conference on Robotics and Automation, 1998, http://www.prop.org/papers/icra98.pdf.
Paulos, "PRoP: Personal Roving Presence", ACM:CHI Proceedings of CHI '98, http://www.prop.org/papers/chi98.pdf.
Paulos, Video of PRoP 2 at Richmond Field Station, www.prop.org. May 2001, Printout of Home Page of Website and two-page Transcript of the audio portion of said PRoP Video.
Rovetta et al., "A New Telerobotic Application: Remote Laparoscopic Surgery Using Satellites and Optical Fiber Networks for Data Exchange", Jun. 1, 1996, International Journal of Robotics Research, pp. 267-279.
Schaeffer, "Care-O-bot: A System for Assisting Elderly or Disabled Persons in Home Environments", Proceedings of AAATE-99, 1999, http://morpha.de/download/publications/IPA_Systems_For_AssistingElderly_or_DisabledPersons_AAATE1999.pdf.
Schulz, "Web Interfaces for Mobile Robots in Public Places", Robotics & Automation Magazine, IEEE, vol. 7, Issue 1, Mar. 2000.
Siegwart, "Interacting Mobile Robots on the Web", Proceedings of the 1999 IEEE International Conference on Robotics and Automation, May 1999.
Simmons, "Xavier: An Autonomous Mobile Robot on the Web", IEEE Robotics and Automation Magazine, 1999, pp. 43-48.
Spawar Systems Center, "Robart", 1998, San Diego, CA, http://web.archive.org/web/*/http://www.nosc.mil/robots/land/robart/robart.html http://web.archive.org/web/19981202205636/http://www.nosc.mil/robots/land/robart/robart.html.
Suplee, "Mastering the Robot", The Washington Post, p. A01, Sep. 17, 2000 http://www.cs.cmu.edu-nursebot/web/press/wash/index.html.
West et al., "Design of Ball Wheel Mechanisms for Omnidirectional Vehicles with Full Mobility and Invariant Kinematics", Journal of Mechanical Design, vol. 119, pp. 153-161, Jun. 1997.
Yamauchi et al., PackBot: A Versatile Platform for Military Robotics, 2004, Internet, pp. 1-10.
Zamrazil, Kristie, "Telemedicine in Texas: Public Policy Concerns", House Research Organization Focus Report, Texas House of Representatives, No. 76-22, May 5, 2000 http://www.hro.house.state.tx.us/focus/telemed.pdf.
Appeal from the U.S. District Court for the Central District of California in case No. 11-cv-9185, Judge Percy Anderson, Joint Appendix, vol. I of IV, Jun. 24, 2013, pp. A1-A6357.
Appeal from the U.S. District Court for the Central District of California in case No. 11-cv-9185, Judge Percy Anderson, Joint Appendix, vol. II of IV, Jun. 24, 2013, pp. A6849-A10634.
Appeal from the U.S. District Court for the Central District of California in case No. 11-cv-9185, Judge Percy Anderson, Joint Appendix, vol. III of IV, Jun. 24, 2013, pp. A10654-A15517.
Appeal from the U.S. District Court for the Central District of California in case No. 11-cv-9185, Judge Percy Anderson, Joint Appendix, vol. IV of IV, Jun. 24, 2013, pp. A15677-A18127.
Brief for Defendant-Appellee VGO Communications, Inc., Appeal from the U.S. District Court for the Central District of California, in Case No. 2:11-cv-9185, Judge Percy Anderson, May 28, 2013, 75 pages.
Civil Minutes—General: Case No. CV 11-9185PA (AJWx), *InTouch Tech., Inc.* v. *VGo Commons, Inc.*, Sep. 10, 2012, 7 pages.
"Magne Charge", Smart Power for Electric Vehicles, Serial No. 75189637, Registration Number: 2114006 Filing Date: Oct. 29, 1996, Aug. 26, 1997, 2 pages.
Opening Brief for Plaintiff—Appellant InTouch Technologies, Inc., Appeal from the U.S. District Court for the Central District of California in Case No. 11-cv-9185, Judge Percy Anderson, Apr. 12, 2013, 187 pages.
Reply Brief for Plaintiff—Appellant InTouch Technologies, Inc., Appeal from the U.S. District Court for the Central District of California in Case No. 11-cv-9185, Judge Percy Anderson, Jun. 14, 2013, 39 pages.
"Using your Infrared Cell Phone Camera", Available on <http://www.catsdomain.com/xray/about.htm>, retrieved on Jan. 23, 2014, Courtesy of Internet Wayback Machine, Jan. 30, 2010, 4 pages.
Office Action received for Chinese Patent Application No. 200680044698.0 on Nov. 4, 2010. (9 pages of Official Copy and 17 pages of English Translation).
Activmedia Robotics LLC, "Pioneer 2/PeopleBotTM", Operations Manual, Version 9, Oct. 2001, 78 pages.
Adams, Chris, "Simulation of Adaptive Behavior (SAB'02)—From Animals to Animats 7", Mobile Robotics Research Group, The Seventh International Conference, available online at <http://www.dai.ed.ac.uk/groups/mrg/MRG.html>, retrieved on Jan. 22, 2014, Aug. 4-11, 2002, 1 page.

(56) **References Cited**

OTHER PUBLICATIONS

Apple Inc., "I Phone", iPhone Series, XP002696350, Sep. 21, 2012, pp. 1-29.
Evans et al., "HelpMate: The Trackless Robotic Courier", PYXIS, available online at <http://www.pyxis.com/>, 3 pages.
Gaidioz et al., "Synchronizing Network Probes to Avoid Measurement Intrusiveness with the Network Weather Service", High-Performance Distributed Computing, Proceedings of the Ninth International Symposium, 2000, pp. 147-154.
Garner et al., "The Application of Telepresence in Medicine", BT Technology Journal, vol. 15, No. 4, Oct. 1, 1997, pp. 181-187.
Jacobs et al., "Applying Telemedicine to Outpatient Physical Therapy", AMIA, Annual Symposium Proceedings, 2002, 1 page.
Kurlowicz et al., "The Mini Mental State Examination (MMSE)", Journal of Psychiatric Research, vol. 12, No. 3, 1975, pp. 189-198.
Lemaire, Edward, "Using Communication Technology to Enhance Rehabilitation Services", Terry Fox Mobile Clinic, The Rehabilitation Centre, Ottawa, Canada, 2001, 96 pages.
Nakazato et al., "Group-Based Interface for Content-Based Image Retrieval", Proceedings of the Working Conference on Advanced Visual Interfaces, 2002, pp. 187-194.
Nakazato et al., "ImageGrouper: A Group-Oriented User Interface for Content-Based Image Retrieval and Digital Image Arrangement", Journal of Visual Languages and Computing, vol. 14, No. 4, Aug. 2003, pp. 363-386.
North, Michael, "Telemedicine: Sample Script and Specifications for a Demonstration of Simple Medical Diagnosis and Treatment Using Live Two-Way Video on a Computer Network", Greenstar Corporation, 1998, 5 pages.
Piquepaille, Roland, "This Blog and its RSS Feed are Moving", Roland Piquepaille's Technology Trends, How New Technologies are Modifying our Way of Life, Oct. 31, 2004, 2 pages.
Radvision, "Making Sense of Bandwidth the NetsenseWay", Network Congestion in Unmanaged Networks Bandwidth Estimation and Adaptation Techniques, Radvision's Netsense Technology, 2010, 7 pages.
Roy et al., "Towards Personal Service Robots for the Elderly", Workshop on Interactive Robots and Entertainment (WIRE 2000), vol. 25, Apr. 30-May 1, 2000, 7 pages. 16.
Telepresence Research, Inc., "Telepresence Mobile Robot System", Available online at <http://www.telepresence.com/telepresence-research/TELEROBOT/>, retrieved on Nov. 23, 2010, Feb. 20, 1995, 3 pages.
Theodosiou et al., "MuLVAT: A Video Annotation Tool Based on XML-Dictionaries and Shot Clustering", 19th International Conference, Artificial Neural Networks—ICANN, Sep. 14-17, 2009, pp. 913-922.
Tyrrell et al., "Teleconsultation in Psychology: The Use ofVideolinks for Interviewing and Assessing Elderly Patients", Age and Ageing, vol. 30 No. 3, May 2001, pp. 191-195.
Weaver et al., "Monitoring and Controling Using the Internet and Java", Proceedings of the 25th Annual Conference of the IEEE Industrial Electronics Society, vol. 3, 1999, pp. 1152-1158.
International Search Report for International Patent Application No. PCT/US2005/037347, Apr. 17, 2006, 2 pages.
International Preliminary Report and Written Opinion Received for International Patent Application No. PCT/US2005/037347, Apr. 17, 2006, 7 pages.
International Preliminary Report on Patentability and Written Opinion Received for International Patent Application No. PCT/US2006/037076, Apr. 1, 2008, 6 pages.
International Search Report and Written Opinion Received for International Application No. PCT/US2006/037076, May 11, 2007, 6 pages.
International Preliminary Report on Patentability and Written Opinion Received for International Patent Application No. PCT/US/200714099, Dec. 16, 2008, 5 pages.
International Search Report Received for international Patent Application No. PCT/US2007/14099, Jul. 30, 2008, 1 page.
"Appeal from the U.S. District Court for the Central District of California in No. 11-CV-9185, Judge Percy Anderson", May 9, 2014, pp. 1-48.
"Google translation of: Innovations Report", From research project to television star: Care-O-bot in ZDF series, available online at <http://www.innovations-report.de/specials/printa.php?id=5157>, Sep. 28, 2001.
"MPEG File Format Summary", downloaded from: <http://www.fileformat.info/format/mpeg/egff.htm>, Feb. 1, 2001, 8 pages.
"MPEG-4: a Powerful Standard for Use in Web and Television Environments", by Rob Koenen (KPN Research), downloaded from <http://www.w3.org/Architecture/1998/06/Workshop/paper26>, Jul. 1, 1998, 4 pages.
CMU Course 16X62, "Robot user's manual", (describing the Nomad Scout), Carnegie Mellon University, Feb. 1, 2001, 11 pages.
Panusopone et al., "Performance comparison of MPEG-4 and H.263+ for streaming video applications", Circuits Systems Signal Processing, vol. 20, No. 3, 2001, pp. 293-309.
Schraft et al., "Care-O-botTM: The Concept of a System for Assisting Elderly or Disabled Persons in Home Environments", IEEE Proceedings of the 24th Annual Conference of the Industrial Electronics Society, IECON '98, Aug. 31-Sep. 4, 1998, pp. 2476-2481.
Nomadic Technologies, Inc., "Nomad Scout User's Manual", Software Version 2.7, Part No. DOC00004, Jul. 12, 1999, pp. 1-59.
ACM Digital Library Record, Autonomous Robots, vol. 11, No. 1, Table of Content, available at <http://dl.acm.org/citation.cfm?id=591550&picked=prox&cfid=360891374&cftoken=35225929>, Jul. 2001, 2 pages.
Brenner, Pablo, "A Technical Tutorial on the IEEE 802.11 Protocol", BreezeCOM Wireless Communications, Jul. 18, 1996, pp. 1-24.
Library of Congress, "008-Fixed-Length Data Elements (NR)", MARC 21 Format for Classification Data, available at <http://www.loc.gov/marc/classification/cd008.html>, retrieved on Jul. 22, 2014, pp. 1-14.
Paulos et al., "Personal Tele-Embodiment", Chapter 9 in Goldberg et al., Ed., "Beyond Webcams", MIT Press, Jan. 4, 2002, pp. 155-167.
Paulos et al., "Social Tele-Embodiment: Understanding Presence", Autonomous Robots, vol. 11, No. 1, Kluwer Academic Publishers, Jul. 2001, pp. 87-95.
Paulos, Eric John, "Personal Tele-Embodiment", Introductory and Cover Pages from 2001 Dissertation Including Contents table, together with E-mails Relating thereto from UC Berkeley Libraties, as Shelved at UC Berkeley Engineering Library (Northern Regional Library Facility), May 8, 2002, 25 pages (including 4 pages of e-mails).
Paulos, Eric John, "Personal Tele-Embodiment", OskiCat Catalog Record, UCB Library Catalog, Results page and MARC Display, retrieved on Jun. 14, 2014, 3 Pages.
Screenshot Showing Google Date for Lemaire Telehealth Manual, Screenshot Retrieved on Dec. 18, 2014, 1 page.
Nomadic Technologies, Inc., "Nomad Scout Language Reference Manual", Software Version: 2.7, Part No. DOC00002, Jul. 12, 1999, 47 pages.
Blaer, et al., "TopBot: Automated Network Topology Detection With a Mobile Robot", Proceedings of the 2003 IEEE International Conference on Robotics 7 Automation, Taipei, Taiwan, Sep. 14-19, 2003, pp. 1582-1587.
Bradner, "The Internet Standards Process—Revision 3", Network Working Group Request for Comments: 2026, www.rfc-e ditor.org!rfC/rfc2026. txt, Oct. 1996, pp. 1-36.
Brooks, "A Robust Layered Control System for a Mobile Robot," IEEE Journal of Robotics and Automation, 2 (1), Mar. 1986, 10 pgs.
Christensen et al., "BeeSoft User's Guide and Reference", Robots for the Real World™, Real World Interface, Inc., www.praecogito.com/-brudy/zaza/BeeSoft-manual-1.2-2/ beeman~1.htm, Sep. 26, 1997, pp. 1-203.
Dario, "A Robot Workstation for Diagnosis and Physical Therapy", IEEE Catalog No. 88TH0234-5, 1989, pp. 67-72.
Gostai, "Robotic Telepresence: Gostai Jazz", Flyer, http://www.gostai.com, n. date, 4 pgs.
Leifer, et al., "VIPRR: A Virtually in Person Rehabilitation Robot", Proceedings of 1997 International Conference on Rehabilitation

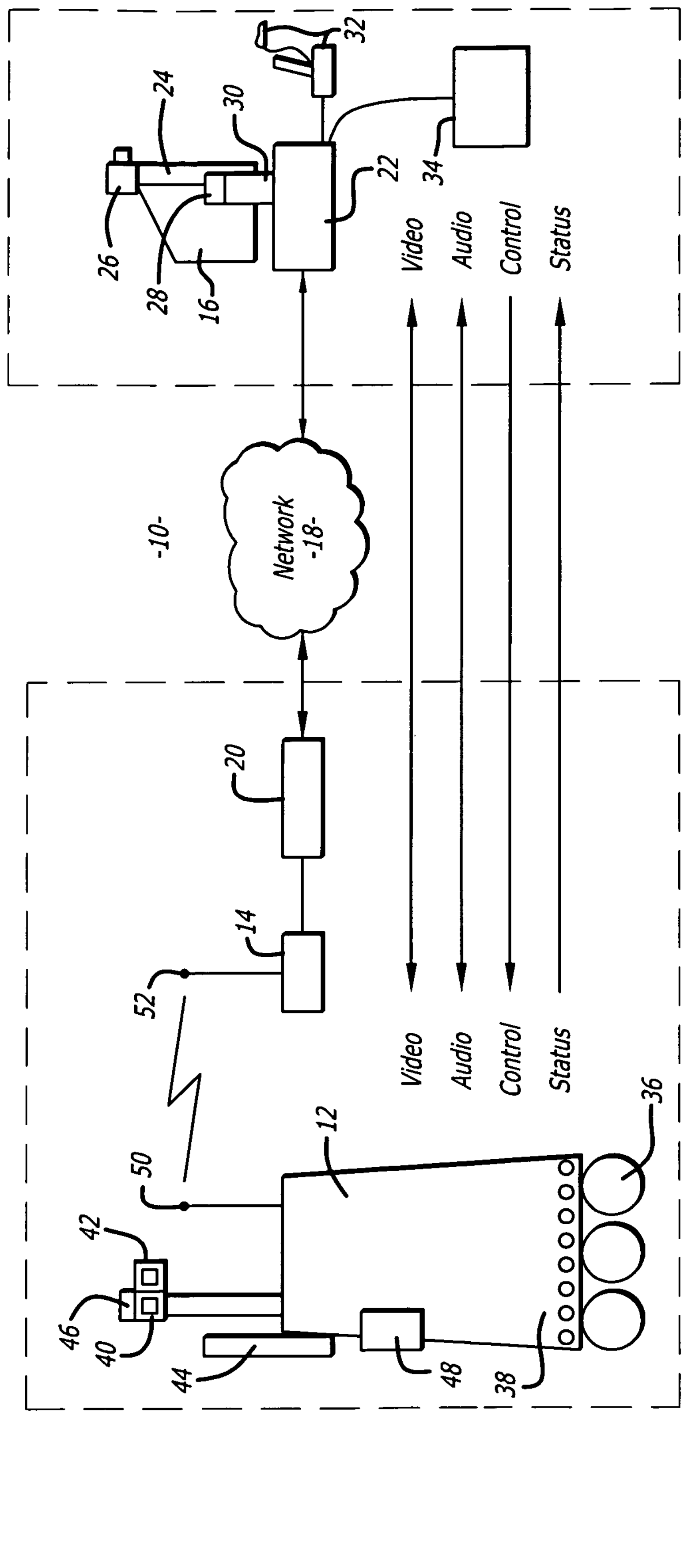
(56) **References Cited**

OTHER PUBLICATIONS

Robotics, http://www.stanford.edu/group/rrdlPeople/vdl/publicationsIICORR97/VIPRR.html, Apr. 14-15, 1997, 4 pgs.
Minsky, "Telepresence", OMNI, Jun. 1980, pp. 1-6.
Motorola Technical Developments, et al., "Detection of Target Mobile Signal Strength", PriorArt Database: Technical Disclosure, IP.com, Retrieved from http: www.ip.com/pubview/IPCOM000009024D, original publication date: Jan. 1, 1999 by Motorola, Inc., pp. 205-206, Aug. 1, 2002, pp. 1583-1587.
Noritsugu, "Application of Rubber Artificial Muscle Manipulator as a Rehabilitation Robot", IEEE/ASME Transations on Mechatronics, vol. 2, No. 4, Dec. 1997, pp. 259-267.
Osborn, "QoLT Research Overview", Quality of Life Technology Center: A National Science Foundation Engineering Research Center, Carnegie Mellon University of Pittsburgh, www.qolt.org, n. date, 2 pgs.
Reynolds et al., "Review of Robotic Telemedicine Utilization in Intensive Care Units (ICUs)", 11th Annual ATA Symposium, Tampa, Florida, 2011, 1 pg.
"Saphira Software Manual", Saphira Version 5.3, ActiveMedia, Inc., 1997, 105 pgs.
Tipsuwan, et al., "Gain Adaptation of Networked Mobile Robot to Compensate QoS Deterioration", IEEE, 2000, pp. 3146-3151.
Tsui, et al., "Exploring Use Cases for Telepresence Robots", Human-Robot Interaction, Lausanne, Switzerland, http://robotics.cs.uml.edu/fileadmin/content/publications/2011/tsui-et-al-telepresence-HRI11.pdf, Robotics Lab UMass Lowell, 2011, 7 pgs.
UMASS Lowell Robotics Lab, "Robotics Lab @ UMASS Lowell", Brochure, http://robotics.cs.uml.edu/fileadmin/content/brochures/roboticslab_brochure_2011_web.pdf, 2011, 2 pgs.
Video Middleware Group, "H.350 Directory Services for Multimedia", http://www.vide.net/resources/h350vendor.pdf, n. date, 2 pgs.
Barrett, "Video Conferencing Business Soars as Companies Cut Travel; Some Travel Cuts Are Permanent", http://www.ivci.com/international_videoconferencing_news_videoconferencing_news_19.html, Mar. 13, 2002.
Davis, "Meet iRobot, The Smartest Webcam on Wheels," Wired Magazine, 8.09, http://www.wired.com/wired/archive/8.09/irobot_pr.html, Sep. 2000, 2 pgs.
Dean, et al., "1992 AAAI Robot Exhibition and Competition," AI Magazine, Spring 1993, 10 pgs.
"Defendant VGo Communications, Inc.'s Invalidity Contentions Pursuant to the Feb. 27, 2012 Civil Minute Order", May 2, 2012.
"Defendant-Counterclaimant VGo Communications, Inc.'s Supplemental Invalidity Contentions Pursuant to the Feb. 27, 2012 Civil Minute Order", May 14, 2012.
Dudenhoeffer, et al., "Command and Control Architectures for Autonomous Micro-Robotic Forces", http://www.inl.gov/technicalpublications/Documents/3157051.pdf, Apr. 2001.
Elhajj, "Real-Time Haptic Feedback in Internet-Based Telerobotic Operation", IEEE International Conference on Electro/Information Technology, http://www.egr.msu.edu/~ralab-web/cgi_bin/internet-teleoperation.php, Jun. 2000.
Fong, "Collaborative Control: A Robot-Centric Model for Vehicle Teleoperation", The Robotics Institute Carnegie Mellon University, http://web.archive.org/web/20030504040803/www.ricmu.edu/cgi-bin/tech_reports.cgi?year=2001&text=0, Nov. 2001.
Goldenberg, et al., "Telemedicine in Otolaryngology", American Journal of Otolaryngology vol. 23, No. 1, 2002 , pp. 35-43.
Grow, "Office Coworker Robot," Time Magazine, http://www.time.com/time/specials/packages/article/0,28804,1936165_1936255_1936640,00.html, Nov. 19, 2001, 2 pgs.
Han, et al., "Construction of an Omnidirectional Mobile Robot Platform Based on Active Dual-Wheel Caster Mechanisms and Development of a Control Simulator", Kluwer Acedemic Publishers, vol. 29, Nov. 2000, pp. 257-275
ITU, "ITU-T H.281 A Far End Camera Control Protocol for Videoconferences using H.224", http://www.itu.int/rec/T-Rech.281-199411-l/en, Nov. 1994.
ITU, "ITU-T H.450.11 Call Intrusion Supplementary Service for H.323", http://www.itu.int/rec/T-Rech.450.11-200103-l/en, Mar. 2001.
ITU, "ITU-T H.450.9 Call Completion Supplementary Services for H.323", http://www.itu.int/rec/T-Rech.450.9-200011-l/en, Nov. 2000.
Knight, et al., "Active Visual Alignment of a Mobile Stereo Camera Platform", Proceedings of the IEEE, International Conference on Robotics and Automation, San Francisco, Apr. 24-28, 2000, pp. 3202-3208.
Metz, "HP Labs", PCMAG.com, http://www.pcmag.com/article2/0,2817,1130820,00.asp, Jul. 1, 2003.
"PictureTel Adds New Features and Functionality to Its Award-Winning Live200 Desktop Videoconferencing System", PR Newswire Association, LLC, Gale, Cengage Learning, http://www.thefreelibrary.com/PictureTel+Adds+New+Features+And+Functionality+To+Its+Award-Winning . . . -a019512804, Jun. 13, 1997.
Picturetel, "PictureTel Live200 for Windows NT Product Guide", http://support.polycom.com/global/documents/support/user/products/video/live200_live200NT_product_guide.pdf, Nov. 1994.
Roach, "Automatic Call Back Service in SIP", http://tools.ietf.org/pdf/draftroach-sip-acb-00.pdf, Mar. 2000.
Summers, "Microsoft NetMeeting 3 Features excerpt from Official Microsoft NetMeeting 3.0 Book", http://technet.microsoft.com/en-us/library/cc723477.aspx#XSLTsection121121120120, excerpt from Microsoft Press http://www.computerbooksonline.com/abook.asp?i=0735605823, Mar. 1999.
Tahboub, Karim A. et al., "Dynamics Analysis and Control of a Holonomic Vehicle With Continously Variable Transmission", Journal of Dynamic Systems, Measurement and Control ASME vol. 124, Mar. 2002, pp. 118-126.
U.S. Appl. No. 10/783,760, filed Feb. 20, 2004, Wang, et al., 48 pgs.
U.S. Appl. No. 60/449,762, filed Feb. 24, 2003, Wang, et al., 28 pgs.
Weiss, Patrice L. et al., "PEBBLES: A Personal Technology for Meeting Education, Social and Emotional Needs of Hospitalised Children", Personal and Ubiquitous Computing 5, Springer-Verlag London Ltd., 2001, pp. 157-168.
Zambroski, "CMU, Pitt Developing 'nursebot'", http://www.cs.cmu.edu/~nursebot/web/press/tribunereview.html, Oct. 27, 2000.

* cited by examiner

FIG. 1


-10-
Network
-18-
Video
Audio
Control
Status
Video
Audio
Control
Status
12
14
16
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
52

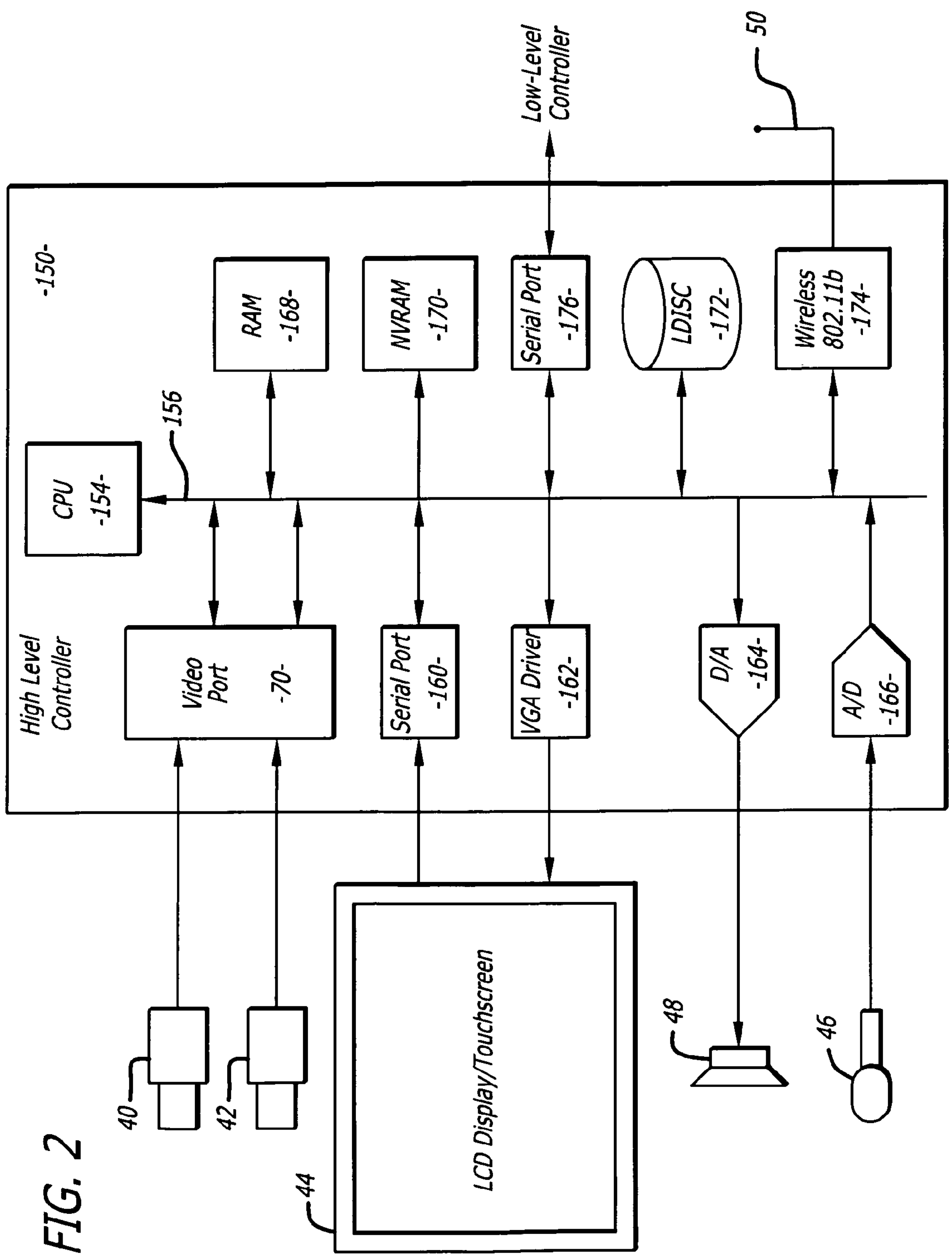

High Level Controller
-150-
CPU -154-
156
RAM -168-
NVRAM -170-
Serial Port -176-
LDISC -172-
Wireless 802.11b -174-
Low-Level Controller
50
Video Port -70-
Serial Port -160-
VGA Driver -162-
D/A -164-
A/D -166-
LCD Display/Touchscreen
44
40
42
48
46

FIG. 2

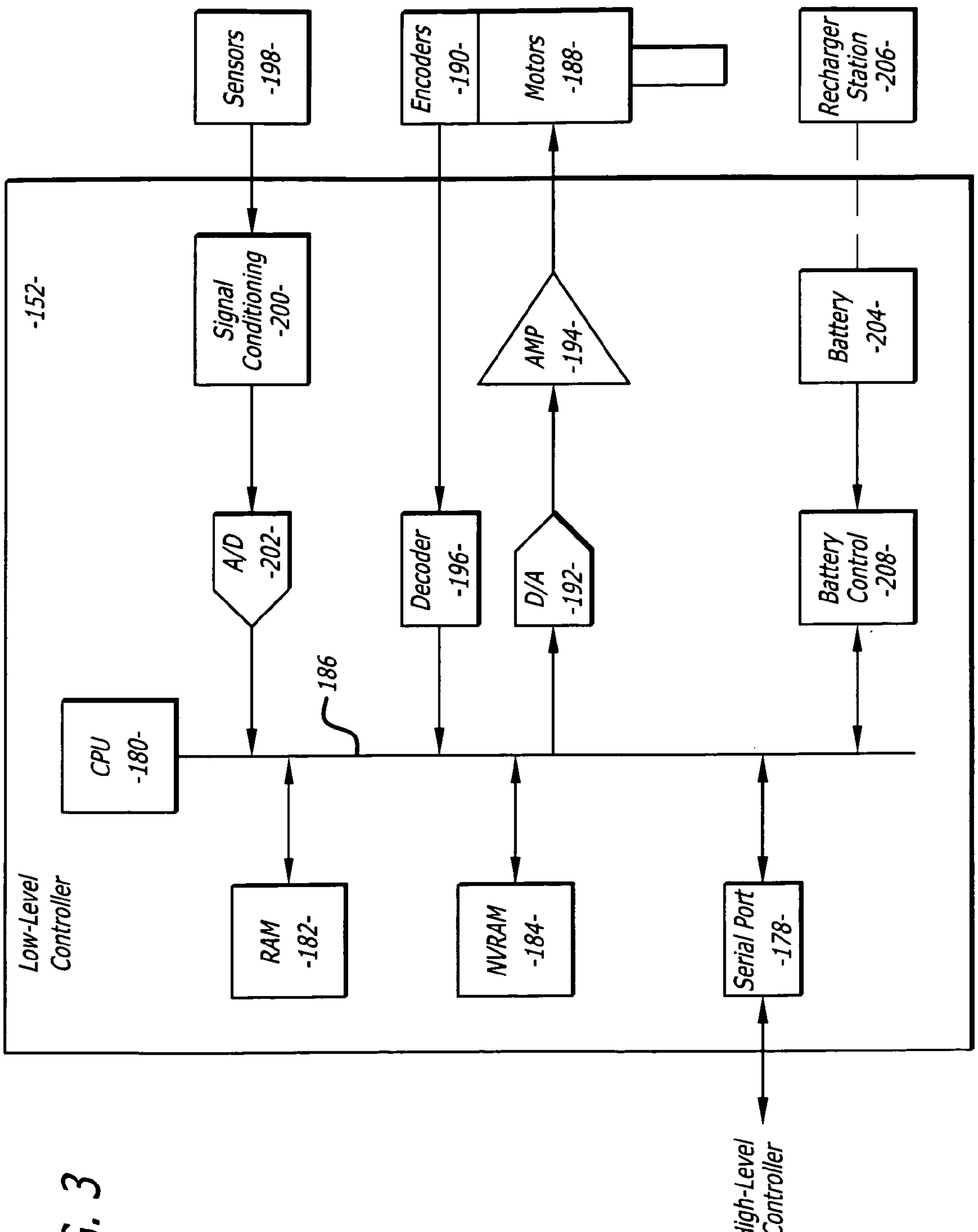

Sensors -198-
Encoders -190-
Motors -188-
Recharger Station -206-
-152-
Signal Conditioning -200-
AMP -194-
Battery -204-
A/D -202-
Decoder -196-
D/A -192-
Battery Control -208-
186
CPU -180-
Low-Level Controller
RAM -182-
NVRAM -184-
Serial Port -178-
High-Level Controller

FIG. 3

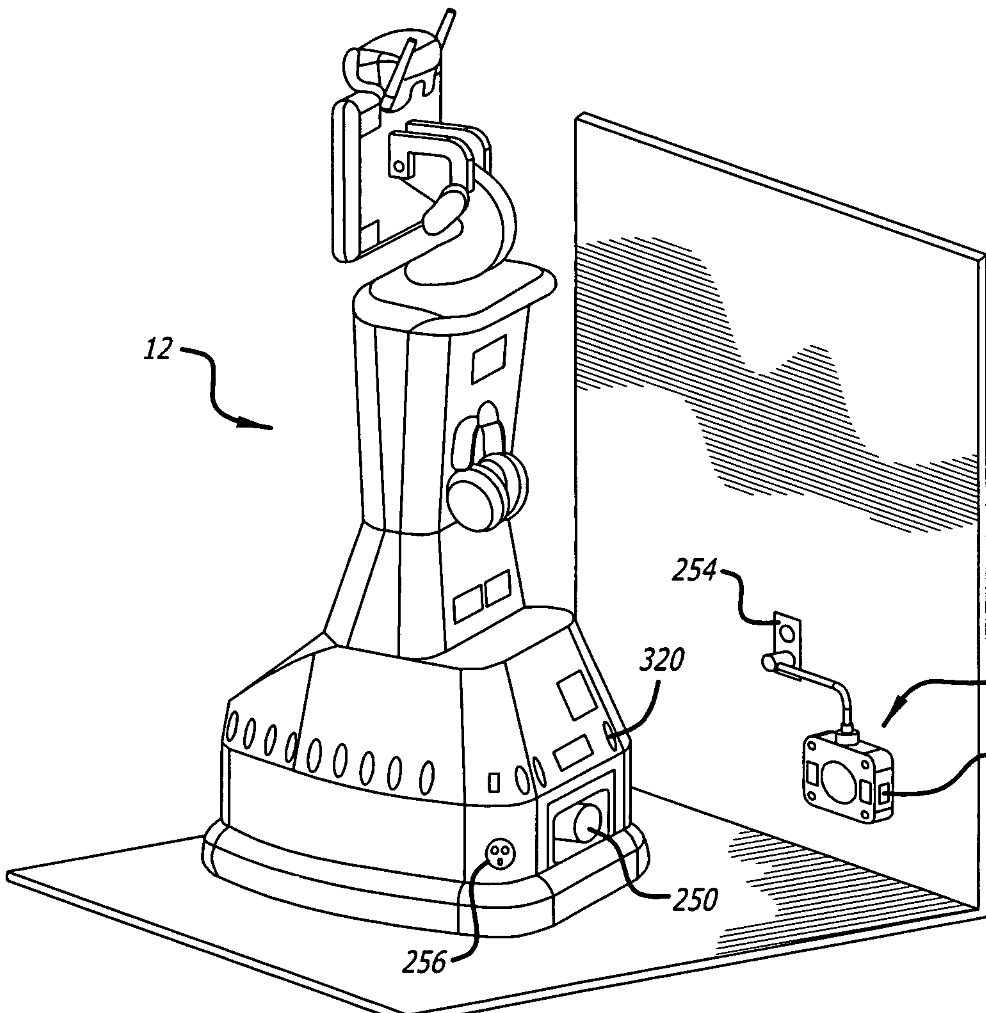


FIG. 4

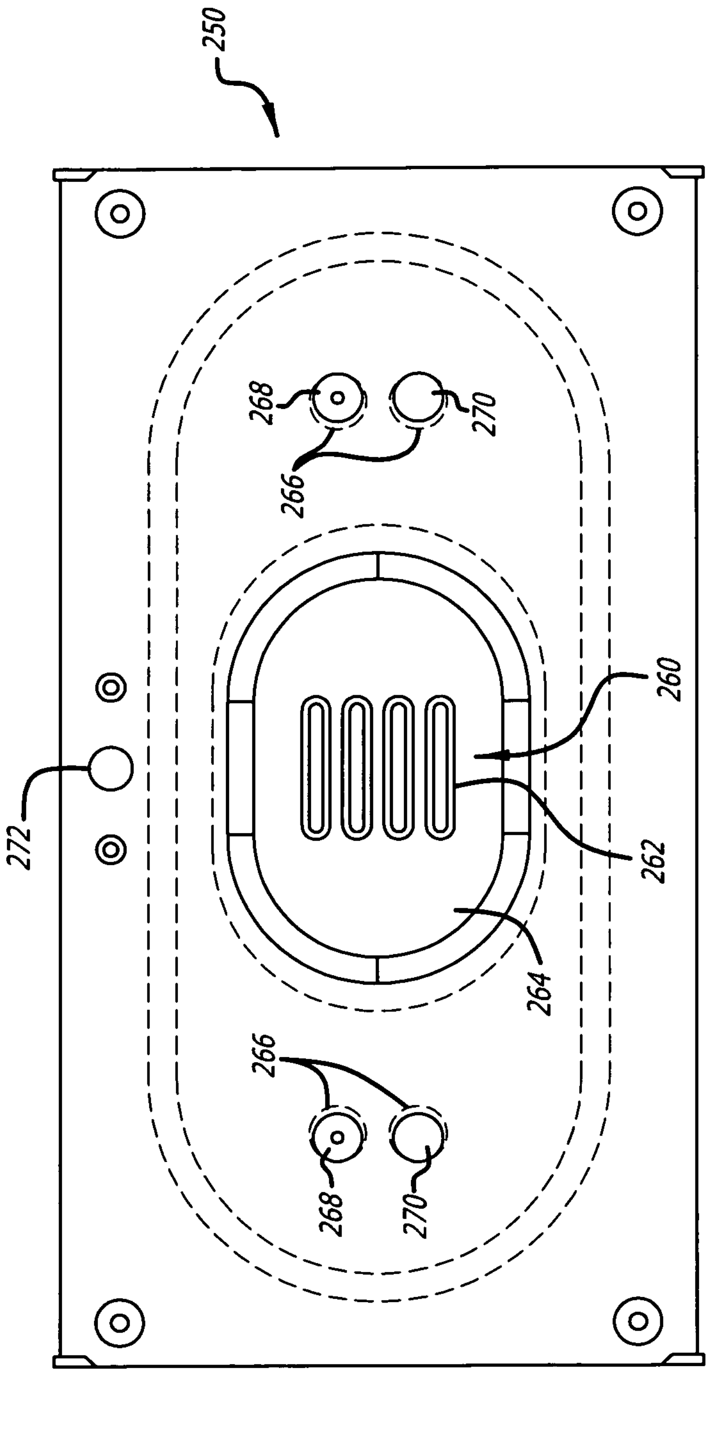


FIG. 5

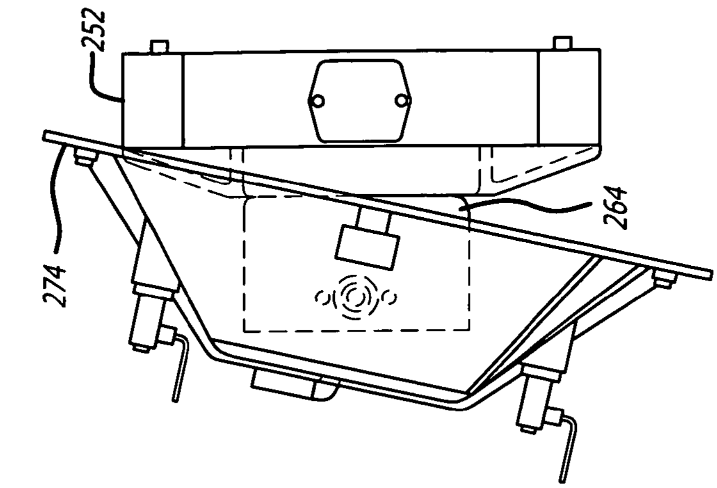


FIG. 6C

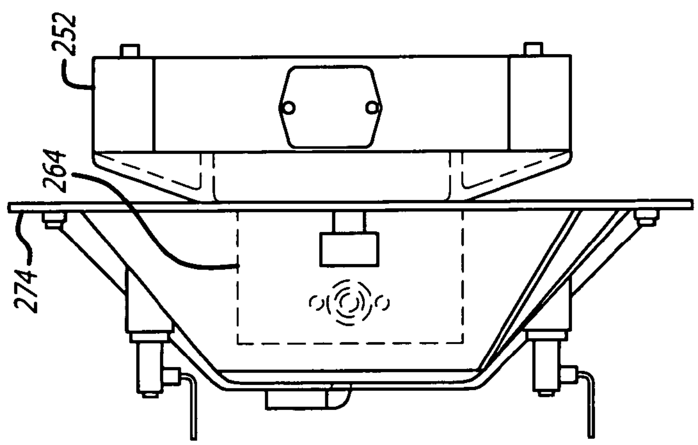


FIG. 6B

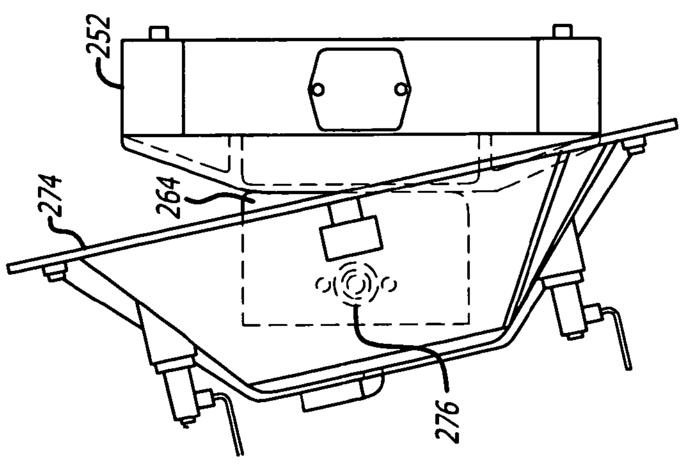


FIG. 6A

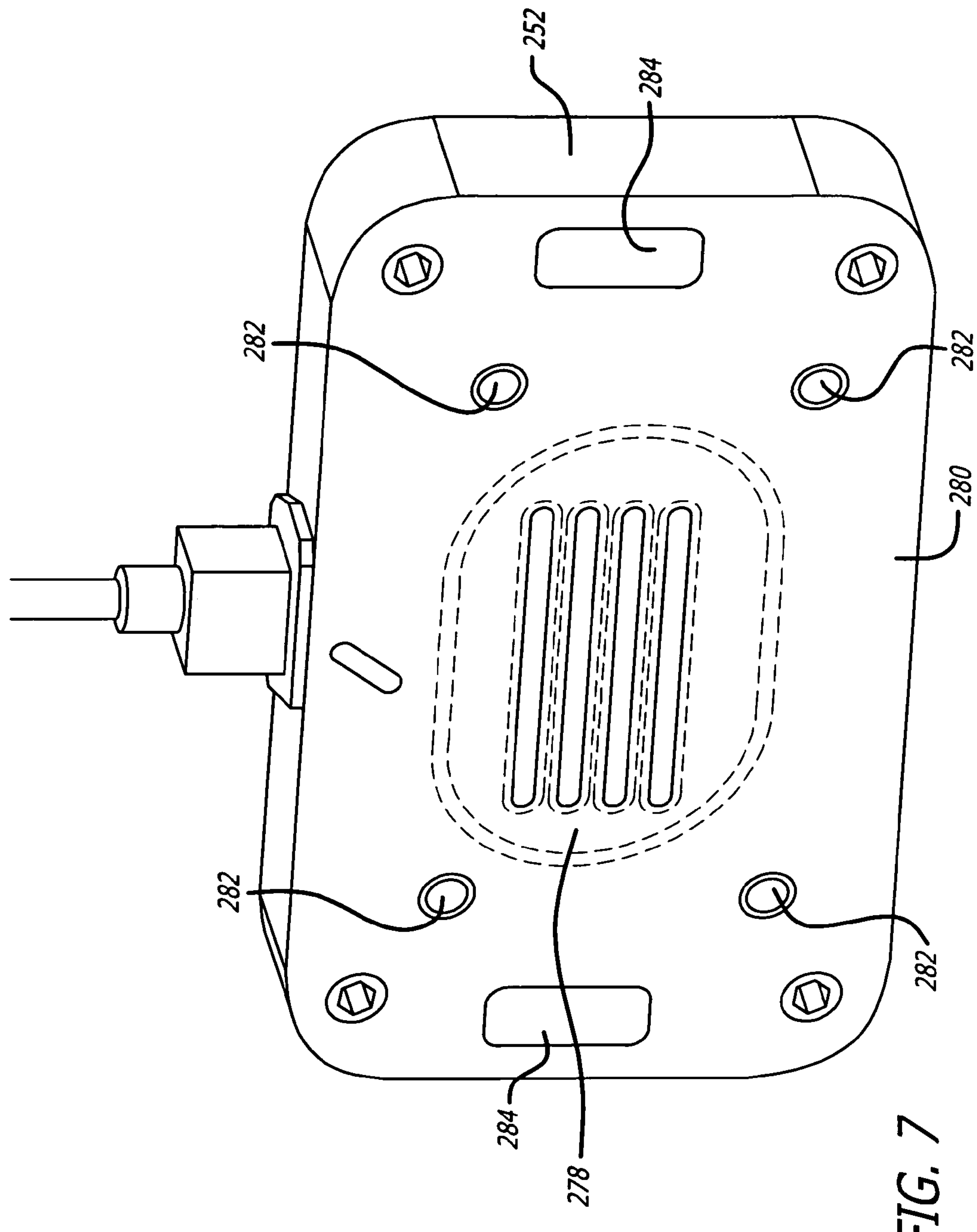


FIG. 7

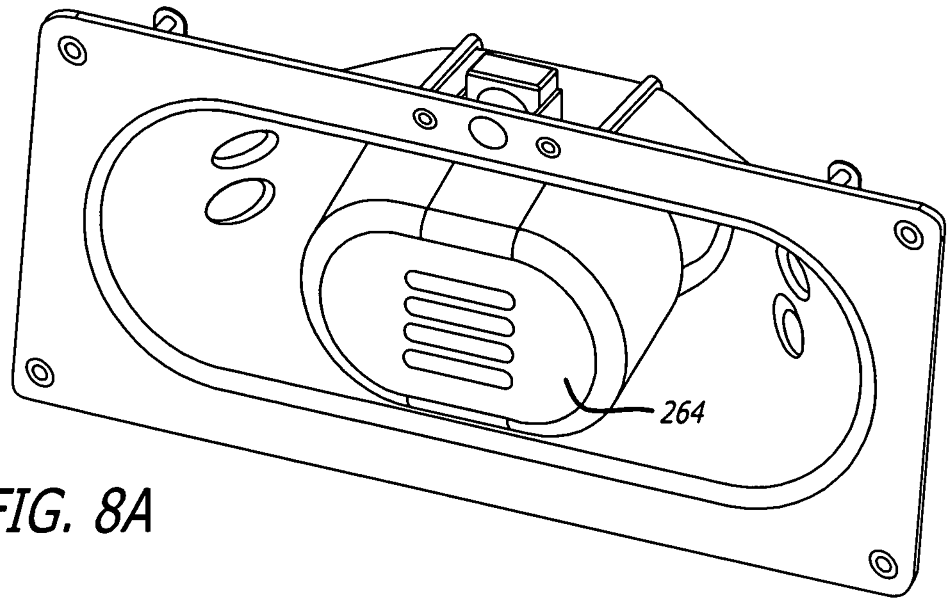


FIG. 8A

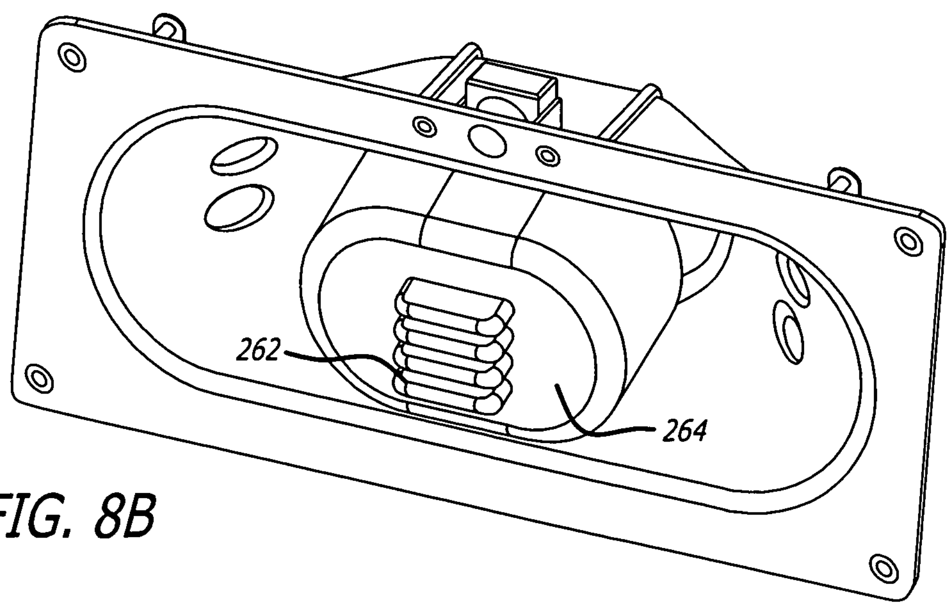


FIG. 8B

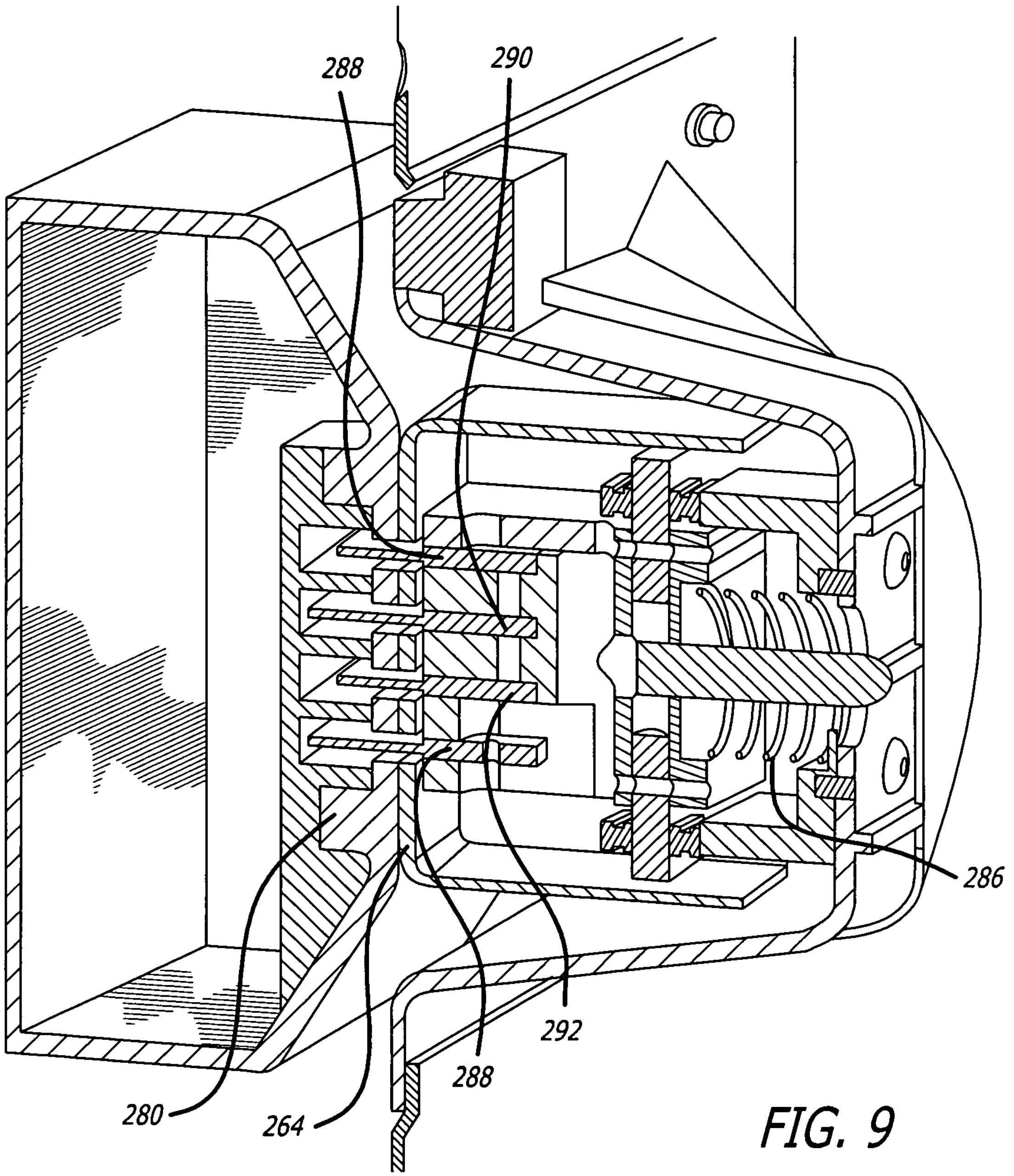


FIG. 9

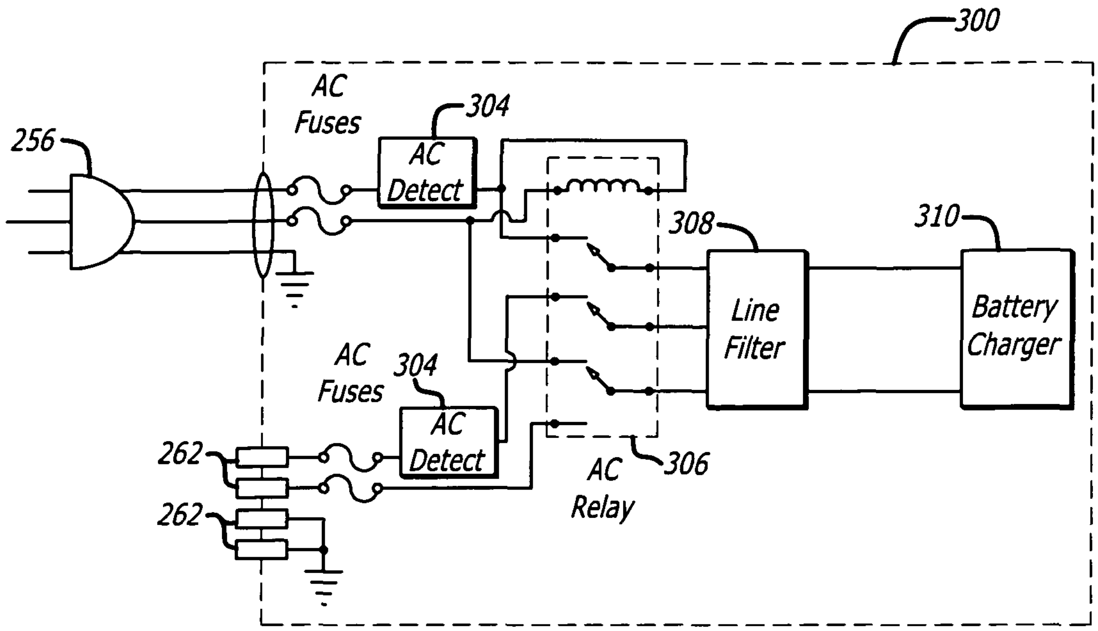


FIG. 10A

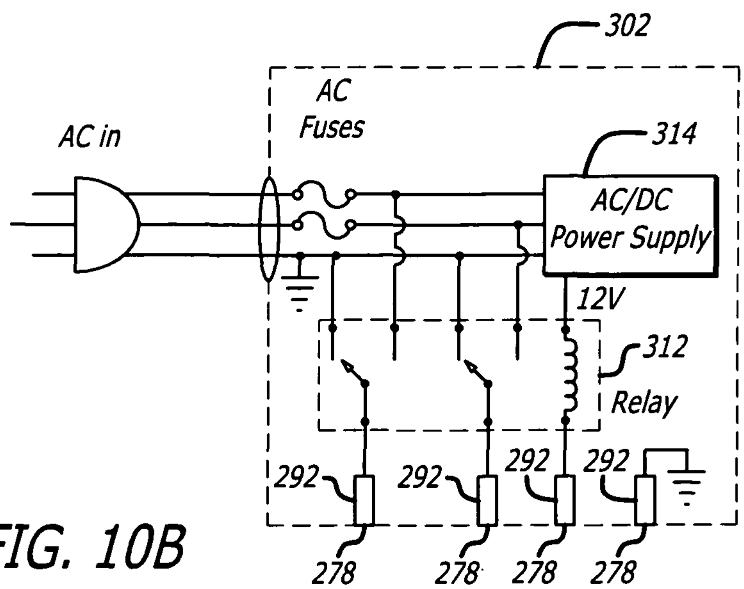


FIG. 10B

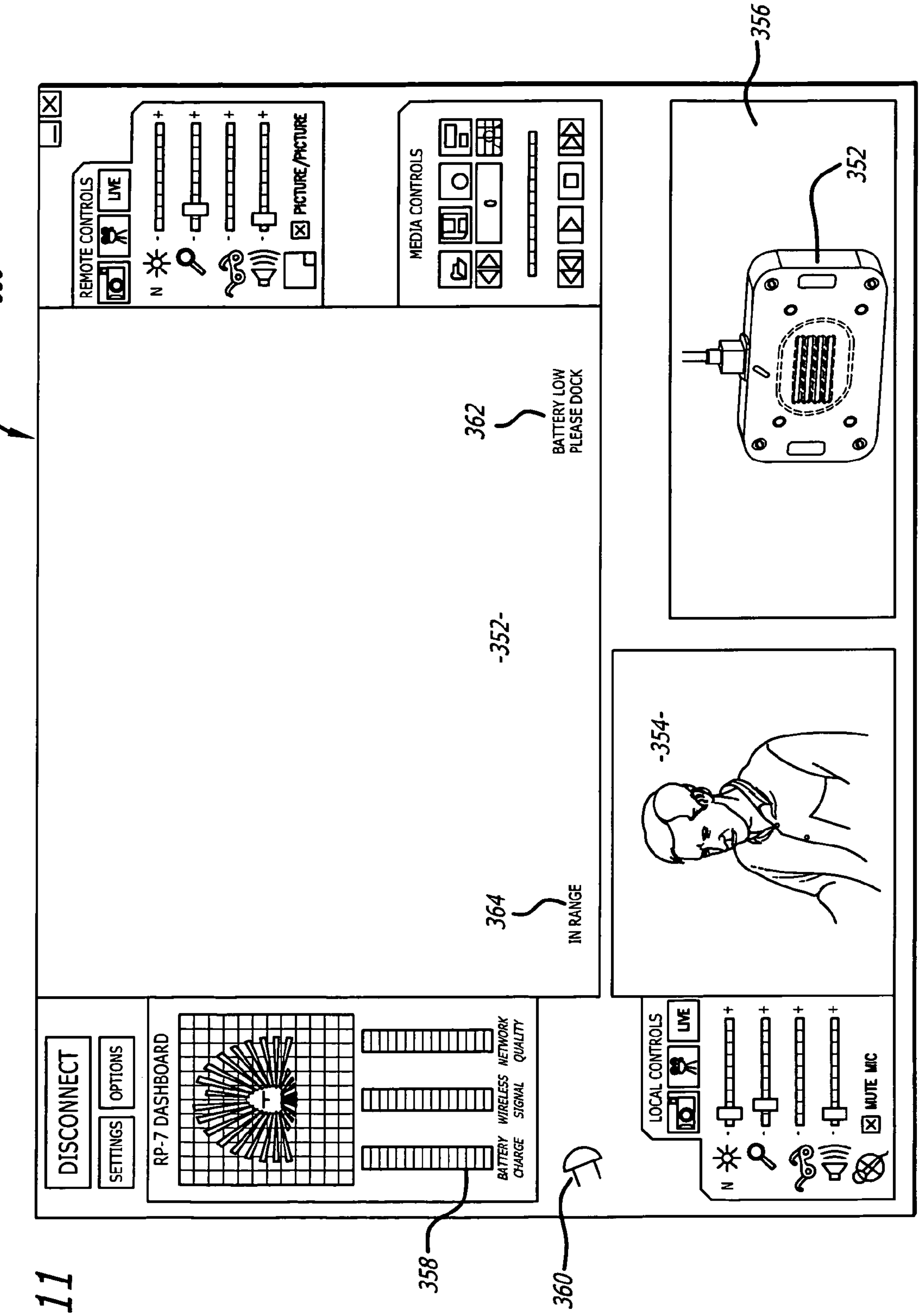

350
356
352
REMOTE CONTROLS
LIVE
PICTURE/PICTURE
MEDIA CONTROLS
362
BATTERY LOW
PLEASE DOCK
-352-
-354-
364
IN RANGE
DISCONNECT
SETTINGS
OPTIONS
RP-7 DASHBOARD
BATTERY CHARGE
WIRELESS SIGNAL
NETWORK QUALITY
LOCAL CONTROLS
LIVE
MUTE MIC
358
360

FIG. 11

DOCKING SYSTEM FOR A TELE-PRESENCE ROBOT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The subject matter disclosed generally relates to the field of mobile robots.

2. Background Information

There has been marketed a mobile robot introduced by InTouch Technologies, Inc., the assignee of this application, under the trademarks COMPANION, RP-6 and RP-7. The InTouch robot is controlled by a user at a remote station. The remote station may be a personal computer with a joystick that allows the user to remotely control the movement of the robot. Both the robot and remote station have cameras, monitors, speakers and microphones to allow for two-way video/audio communication. The robot camera provides video images to a screen at the remote station so that the user can view the robot's surroundings and move the robot accordingly.

The InTouch robot is wireless and thus must operate on battery power. The robot battery must be periodically recharged. This requires remotely moving the robot to an electrical outlet and then having someone at the robot site plug the robot into the outlet. There may be situations where the robot must be recharged but there is no one at the robot site to plug the robot into an electrical outlet.

BRIEF SUMMARY OF THE INVENTION

A remote controlled robot system that includes a mobile robot with a robot camera and a battery plug module, and a remote control station that transmits commands to control the mobile robot. The system also includes a battery charging module that mates with the mobile robot battery plug module, and an alignment system that aligns the battery plug module with the battery charging module.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an illustration of a robotic system;

FIG. **2** is a schematic of an electrical system of a robot;

FIG. **3** is a further schematic of the electrical system of the robot;

FIG. **4** is an illustration of a system with a charging station;

FIG. **5** is an illustration of a battery plug module of a robot;

FIGS. **6**A-C are illustrations showing a plug of the plug module pivoting relative to a shroud;

FIG. **7** is an illustration of a battery charging module;

FIGS. **8**A-B are illustrations showing the exposure of electrical contacts of the battery plug module;

FIG. **9** is an illustration showing a cross-sectional view of the battery plug module mated with the battery charging module;

FIG. **10** is an electrical schematic of the battery plug module and the battery charging module;

FIG. **11** is a graphical user interface of a remote station.

DETAILED DESCRIPTION

Disclosed is a remote controlled robot system that includes a mobile robot with a robot camera and a battery plug module, and a remote control station that transmits commands to control the mobile robot. The system also includes a battery charging module that mates with the mobile robot battery plug module, and an alignment system that aligns the battery

plug module with the battery charging module. The battery modules may also be aligned with the aid of video images of the battery charging module provided to the remote station by a camera located within the battery plug module.

Referring to the drawings more particularly by reference numbers, FIG. **1** shows a robotic system **10** that can be used to conduct a remote visit. The robotic system **10** includes a robot **12**, a base station **14** and a remote control station **16**. The remote control station **16** may be coupled to the base station **14** through a network **18**. By way of example, the network **18** may be either a packet switched network such as the Internet, or a circuit switched network such has a Public Switched Telephone Network (PSTN) or other broadband system. The base station **14** may be coupled to the network **18** by a modem **20** or other broadband network interface device. By way of example, the base station **14** may be a wireless router. Alternatively, the robot **12** may have a direct connection to the network thru for example a satellite.

The remote control station **16** may include a computer **22** that has a monitor **24**, a camera **26**, a microphone **28** and a speaker **30**. The computer **22** may also contain an input device **32** such as a joystick and/or a mouse and a keyboard **34**. The control station **16** is typically located in a place that is remote from the robot **12**. Although only one remote control station **16** is shown, the system **10** may include a plurality of remote stations. In general any number of robots **12** may be controlled by any number of remote stations **16** or other robots **12**. For example, one remote station **16** may be coupled to a plurality of robots **12**, or one robot **12** may be coupled to a plurality of remote stations **16**, or a plurality of robots **12**.

Each robot **12** includes a movement platform **36** that is attached to a robot housing **38**. Also attached to the robot housing **36** is a pair of cameras **40** and **42**, a monitor **44**, a microphone(s) **46** and a speaker(s) **48**. The microphone **46** and speaker **30** may create a stereophonic sound. The robot **12** may also have an antenna **50** that is wirelessly coupled to an antenna **52** of the base station **14**. The robot monitor **44** and cameras **40** and **82** move together in two degrees of freedom including pan and tilt directions. The system **10** allows a user at the remote control station **16** to move the robot **12** through operation of the input device **32**. The robot cameras **40** and **42** are coupled to the remote monitor **24** so that a user at the remote station **16** can view the remote site. Likewise, the robot monitor **44** is coupled to the remote camera **26** so that the someone at the remote site can view the user. The microphones **28** and **46**, and speakers **30** and **48**, allow for audible communication between the patient and the user.

Camera **40** may provide a wide angle view. Conversely, camera **42** may contain a zoom lens to provide a narrow angle view. Camera **42** can capture a zoom image that is transmitted to the remote control station. Camera **40** can capture a non-zoom image that can be transmitted to the remote control station. Although two cameras are shown and described, it is to be understood that the robot may contain only one camera that has the capability to provide a zoom image and a non-zoom image.

The remote station computer **22** may operate Microsoft OS software and WINDOWS XP or other operating systems such as LINUX. The remote computer **22** may also operate a video driver, a camera driver, an audio driver and a joystick driver. The video images may be transmitted and received with compression software such as MPEG CODEC.

FIGS. **2** and **3** show an embodiment of a robot **12**. Each robot **12** may include a high level control system **150** and a low level control system **152**. The high level control system **150** may include a processor **154** that is connected to a bus **156**. The monitor **44** is coupled to the bus **156** by a serial output port **160** and a VGA driver **162**. The monitor **44** may include a touchscreen function that allows a user to enter input by touching the monitor screen.

The speaker **48** is coupled to the bus **156** by a digital to analog converter **164**. The microphone **46** is coupled to the bus **156** by an analog to digital converter **166**. The high level controller **150** may also contain random access memory (RAM) device **168**, a non-volatile RAM device **170** and a mass storage device **172** that are all coupled to the bus **156**. The mass storage device **172** may contain files that can be accessed by the user at the remote control station **16**. For example, the mass storage device **172** may contain a picture of a patient. The user, particularly a health care provider, can recall the old picture and make a side by side comparison on the monitor **24** with a present video image of the patient provided by the camera **40**. The robot antennae **50** may be coupled to a wireless transceiver **174**. By way of example, the transceiver **174** may transmit and receive information in accordance with IEEE 802.11b.

The controller **154** may operate with a LINUX OS operating system. The controller **154** may also operate MS WINDOWS along with video, camera and audio drivers for communication with the remote control station **16**. Video information may be transceived using MPEG CODEC compression techniques. The software may allow the user to send e-mail to the patient and vice versa, or allow the patient to access the Internet. In general the high level controller **150** operates to control communication between the robot **12** and the remote control station **16**.

The remote control station **16** may include a computer that is similar to the high level controller **150**. The computer would have a processor, memory, I/O, software, firmware, etc. for generating, transmitting, receiving and processing information.

The high level controller **150** may be linked to the low level controller **152** by serial ports **176** and **178**. The low level controller **152** includes a processor **180** that is coupled to a RAM device **182** and non-volatile RAM device **184** by a bus **186**. Each robot **12** contains a plurality of motors **188** and motor encoders **190**. The motors **188** can actuate the movement platform and move other parts of the robot such as the monitor and camera. The encoders **190** provide feedback information regarding the output of the motors **188**. The motors **188** can be coupled to the bus **186** by a digital to analog converter **192** and a driver amplifier **194**. The encoders **190** can be coupled to the bus **186** by a decoder **196**. Each robot **12** also has a number of proximity sensors **198** (see also FIG. **1**). The position sensors **198** can be coupled to the bus **186** by a signal conditioning circuit **200** and an analog to digital converter **202**.

The low level controller **152** runs software routines that mechanically actuate the robot **12**. For example, the low level controller **152** provides instructions to actuate the movement platform to move the robot **12**. The low level controller **152** may receive movement instructions from the high level controller **150**. The movement instructions may be received as movement commands from the remote control station or another robot. Although two controllers are shown, it is to be understood that each robot **12** may have one controller, or more than two controllers, controlling the high and low level functions.

The system **10** may be the same or similar to a robotic system provided by the assignee InTouch-Health, Inc. of Santa Barbara, Calif. under the name RP-7. The system may also be the same or similar to the system disclosed in U.S. Pat. No. 6,925,357 issued to Wang et al. on Aug. 2, 2005, which is hereby incorporated by reference.

The various electrical devices of each robot **12** may be powered by a battery(ies) **204**. The battery **204** may be recharged by a battery charger station **206**. The low level controller **152** may include a battery control circuit **208** that senses the power level of the battery **204**. The low level controller **152** can sense when the power falls below a threshold and then send a message to the high level controller **150**.

The low level **152** and/or high level **150** controllers can operate a software routine to automatically dock the robot with the battery charger station **206**.

FIG. **4** is an embodiment of a mobile robot **12** with a battery plug module **250** that can be mated with a battery charging module **252** to recharge the battery of the robot **12**. The battery charging module **252** can be mounted to a wall and plugged into a conventional electrical outlet **254**. The robot **12** may also have a conventional two or three prong electrical plug **256** that can be plugged into the outlet **254** or a similar female outlet **258** on the module **252**.

As shown in FIG. **5** the battery plug module **250** may include a plug **260** that includes a plurality of electrical contacts **262** coupled to a plug housing **264**. The plug module **250** may have sensors **266**. Each sensor **266** may include an IR emitter **268** and an IR detector **270**. The plug module **250** may also include a camera **272** that can provide video images of the battery charging module to the remote station so that the remote operator can move the robot in a manner to mate the modules **250** and **252**.

As shown in FIGS. **6**A-C the contact housing **264** may be pivotally connected to a shroud **274**. The pivotal movement of the housing **264** compensates for any lack of alignment between the plug module **250** and the charging module **252**. The housing **264** can pivot about a pin **276** that is connected to the shroud **274**. The shroud **274** is fixed to the body of the robot **12**.

FIG. **7** shows the battery charging module **252** with a plurality of female electrical receptacles **278** attached to a module housing **280**. The charging module may have a plurality of IR emitters **282** such as IR LEDs. Located on opposite sides of the receptacles **278** are short pass optical filters **284**. The filters **284** can absorb the IR emitted by the plug module **250**.

As shown in FIGS. **8**A-B and **9** the plug module **250** may have a spring **286** that biases the plug housing **264** so that the electrical contacts **262** are normally concealed. When the modules **250** and **252** are mated the charging module housing **280** pushes the plug housing **264** to expose the contacts **262**. This provides a safety feature to prevent inadvertent contact with the electrical contacts **262** during use of the robot **12**. The contacts **262** may include two live contacts **288**, a long ground contact **290** and a short ground contact **292**. The long ground contact **290** can insure grounding when the modules **250** and **252** are initially mated. The short ground contact **290** can be used to control when the charging module is energized.

FIG. **10** is an electrical schematic of a battery plug module circuit **300** and a battery charging module circuit **302**. The plug module circuit **300** includes AC detection circuits **304** that can sense the presence of power and a relay **306** that switch a line filter **308** and battery charger **310** between the electrical contacts **262** and the power plug **256**. If the AC detector **304** for the plug **256** detects power, then the relay **306** couples the charger **310** to the plug **256**. If the contact AC detector **304** detects power, then the relay **306** couples the charger **310** to the contacts **262**.

The charging module circuit **302** includes a relay **312** that can couple the receptacles **278** to a power supply **314**. When the plug module is not mated with the charging module the relay **312** can couple the receptacles **278** to ground, to de-energize the module **252**. When the short ground contact of the plug module is plugged into the corresponding receptacle, the relay **312** switches so that the receptacles **278** are coupled to the power supply **314** to energize the charging module **252** and charge the robot battery. The short ground contact insures that the modules are fully mated before the charging module is energized to improve the safety of the system.

Referring to FIG. **4**, the robot **12** may have a plurality of range finder sensors **320** that emit and receive signals to determine a distance from the robot and an object such as the wall that supports the battery charging module.

FIG. **11** shows a display user interface ("DUI") **350** that can be displayed at the remote station **16**. The DUI **350** may include a robot view field **352** that displays a video image provided by one of the cameras **40** or **42** at the robot location. The DUI **350** may include a station view field **354** that displays a video image provided by the camera of the remote station **16**. The DUI **350** may be part of an application program stored and operated by the computer **22** of the remote station **16**.

The DUI **350** may include a battery camera field **356** that displays a video image provided by the camera of the battery plug module **352**. This field **356** may be used by the user to guide the robot plug into the charging module **352**. The DUI **350** may have a graphical indicator **358** that provides an indication of when the robot battery needs to be recharged. A graphical icon **360** may be selected by the user to enable an automatic docking function of the robot.

While the robot is being operated a "BATTERY LOW PLEASE DOCK" **362** message may appear in field **352**. The user can move the robot until it is in range with the battery charging module. When in range, an "IN RANGE" **364** message may appear in field **352**. When in range the icon **360** can be enabled so that the user can select the automatic docking mode. The range of the robot relative to the charging station may be determined using a RFID tag in the charging station that emits a wireless signal that is detected by an RFID sensor in the robot. Determining whether the robot is in range may also be performed with a visual detection system. By way of example, the visual detection system may be a detection algorithm known as SIFT or a feature detection system provided by Evolution Robotics under the product designation ViPR.

In operation, the robot **12** is placed at a remote site such as a home or a facility where one or more patients are to be monitored and/or assisted. The facility may be a hospital or a residential care facility. By way of example, the robot **12** may be placed in a home where a health care provider may monitor and/or assist the patient. Likewise, a friend or family member may communicate with the patient. The cameras and monitors at both the robot and remote control stations allow for teleconferencing between the patient and the person at the remote station(s).

When the robot **12** is to be recharged the user can move the robot into proximity of the battery charging module. The user can use the image provided by the battery plug module camera to steer the robot so that the battery plug module mates with the battery charging module. The charging module may have a visual indicator that can be used to properly align the plug module with the charging module.

As another mode of operation, the robot may enter an automatic docking mode. The automatic docking mode may be selected by the user through the graphical icon of DUI. Referring to FIGS. **4**, **5** and **7**, in the automatic docking mode the range finder sensors **320** are used to determine a distance from the wall. An algorithm is employed to move the robot **12** until parallel with the wall. The distances from the wall to each sensor can be used to calculate a best fit line for the wall. By way of example, a linear regression technique can be utilized to calculate the slope of the line move the robot until the slope is equal to zero.

After the robot is moved into a position parallel with the wall, the robot can be laterally aligned with the battery charging station. The IR emitters **268** of the battery plug module emit IR light that is reflected and detected by the plug module **250** IR detectors **270**. When the IR emitters are aligned with the short pass filters **284** of the charging module **252**, the IR is absorbed by the filters and not detected. The robot controller (s) can move the robot until the IR is no longer detected. The IR detectors **270** sense the IR emitted from the charging module emitters **282** to detect a lateral relationship between the module **250** and **252**. The robot controller(s) moves the robot until the lateral relationship is detected. When the plug module is laterally located and parallel with the charging module the robot controller can move the robot so that the modules are mated. The modules can be decoupled by moving the robot away from the battery charging module, either through remote operation or automatically.

The robot **12** can be maneuvered throughout the remote site by manipulating the input device **32** at a remote station **16**. The robot **10** may be controlled by a number of different users. To accommodate for this the robot may have an arbitration system. The arbitration system may be integrated into the operating system of the robot **12**. For example, the arbitration technique may be embedded into the operating system of the high-level controller **150**.

By way of example, the users may be divided into classes that include the robot itself, a local user, a caregiver, a doctor, a family member, or a service provider. The robot **12** may override input commands that conflict with robot operation. For example, if the robot runs into a wall, the system may ignore all additional commands to continue in the direction of the wall. A local user is a person who is physically present with the robot. The robot could have an input device that allows local operation. For example, the robot may incorporate a voice recognition system that receives and interprets audible commands.

A caregiver is someone who remotely monitors the patient. A doctor is a medical professional who can remotely control the robot and also access medical files contained in the robot memory. The family and service users remotely access the robot. The service user may service the system such as by upgrading software, or setting operational parameters.

The robot **12** may operate in one of two different modes; an exclusive mode, or a sharing mode. In the exclusive mode only one user has access control of the robot. The exclusive mode may have a priority assigned to each type of user. By way of example, the priority may be in order of local, doctor, caregiver, family and then service user. In the sharing mode two or more users may share access with the robot. For example, a caregiver may have access to the robot, the caregiver may then enter the sharing mode to allow a doctor to also access the robot. Both the caregiver and the doctor can conduct a simultaneous tele-conference with the patient.

The arbitration scheme may have one of four mechanisms; notification, timeouts, queue and call back. The notification mechanism may inform either a present user or a requesting user that another user has, or wants, access to the robot. The timeout mechanism gives certain types of users a prescribed amount of time to finish access to the robot. The queue mechanism is an orderly waiting list for access to the robot. The call back mechanism informs a user that the robot can be accessed. By way of example, a family user may receive an e-mail message that the robot is free for usage. Tables I and II, show how the mechanisms resolve access request from the various users.

TABLE I

User	Access Control	Medical Record	Command Override	Software/Debug Access	Set Priority
Robot	No	No	Yes (1)	No	No
Local	No	No	Yes (2)	No	No
Caregiver	Yes	Yes	Yes (3)	No	No
Doctor	No	Yes	No	No	No

TABLE I-continued

User	Access Control	Medical Record	Command Override	Software/Debug Access	Set Priority
Family	No	No	No	No	No
Service	Yes	No	Yes	Yes	Yes

TABLE II

		Requesting User				
		Local	Caregiver	Doctor	Family	Service
Current User	Local	Not Allowed	Warn current user of pending user Notify requesting user that system is in use Set timeout	Warn current user of pending user Notify requesting user that system is in use Set timeout = 5 m	Warn current user of pending user Notify requesting user that system is in use Set timeout = 5 m Call back	Warn current user of pending user Notify requesting user that system is in use No timeout Call back
	Caregiver	Warn current user of pending user. Notify requesting user that system is in use. Release control	Not Allowed	Warn current user of pending user Notify requesting user that system is in use Set timeout = 5 m Queue or callback	Warn current user of pending user Notify requesting user that system is in use Set timeout = 5 m	Warn current user of pending user Notify requesting user that system is in use No timeout Callback
	Doctor	Warn current user of pending user Notify requesting user that system is in use Release control	Warn current user of pending user Notify requesting user that system is in use Set timeout = 5 m	Warn current user of pending user Notify requesting user that system is in use No timeout Callback	Notify requesting user that system is in use No timeout Queue or callback	Warn current user of pending user Notify requesting user that system is in use No timeout Callback
	Family	Warn current user of pending user Notify requesting user that system is in use Release Control	Notify requesting user that system is in use No timeout Put in queue or callback	Warn current user of pending user Notify requesting user that system is in use Set timeout = 1 m	Warn current user of pending user Notify requesting user that system is in use Set timeout = 5 m Queue or callback	Warn current user of pending user Notify requesting user that system is in use No timeout Callback
	Service	Warn current user of pending user Notify requesting user that system is in use No timeout	Notify requesting user that system is in use No timeout Callback	Warn current user of request Notify requesting user that system is in use No timeout Callback	Warn current user of pending user Notify requesting user that system is in use No timeout Queue or callback	Not Allowed

The information transmitted between the station **16** and the robot **12** may be encrypted. Additionally, the user may have to enter a password to enter the system **10**. A selected robot is then given an electronic key by the station **16**. The robot **12** validates the key and returns another key to the station **16**. The keys are used to encrypt information transmitted in the session.

The robot **12** and remote station **16** transmit commands through the broadband network **18**. The commands can be generated by the user in a variety of ways. For example, commands to move the robot may be generated by moving the joystick **32** (see FIG. **1**). The commands are preferably assembled into packets in accordance with TCP/IP protocol. Table III provides a list of control commands that are generated at the remote station and transmitted to the robot through the network.

TABLE III

Control Commands		
Command	Example	Description
drive	drive 10.0 0.0 5.0	The drive command directs the robot to move at the specified velocity (in cm/sec) in the (x, y) plane, and turn its facing at the specified rate (degrees/sec).
goodbye	goodbye	The goodbye command terminates a user session and relinquishes control of the robot
gotoHomePosition	gotoHomePosition 1	The gotoHomePosition command moves the head to a fixed “home” position (pan and tilt),

TABLE III-continued

Control Commands		
Command	Example	Description
		and restores zoom to default value. The index value can be 0, 1, or 2. The exact pan/tilt values for each index are specified in robot configuration files.
head	head vel pan 5.0 tilt 10.0	The head command controls the head motion. It can send commands in two modes, identified by keyword: either positional ("pos") or velocity ("vol"). In velocity mode, the pan and tilt values are desired velocities of the head on the pan and tilt axes, in degree/sec. A single command can include just the pan section, or just the tilt section, or both.
keepalive	keepalive	The keepalive command causes no action, but keeps the communication (socket) link open so that a session can continue. In scripts, it can be used to introduce delay time into the action.
odometry	odometry 5	The odometry command enables the flow of odometry messages from the robot. The argument is the number of times odometry is to be reported each second. A value of 0 turns odometry off.
reboot	reboot	The reboot command causes the robot computer to reboot immediately. The ongoing session is immediately broken off.
restoreHeadPosition	restoreHeadPosition	The restoreHeadposition functions like the gotoHomePosition command, but it homes the head to a position previously saved with gotoHomePosition.
saveHeadPosition	saveHeadPosition	The saveHeadPosition command causes the robot to save the current head position (pan and tilt) in a scratch location in temporary storage so that this position can be restored. Subsequent calls to "restoreHeadPosition" will restore this saved position. Each call to saveHeadPosition overwrites any previously saved position.
setCameraFocus	setCameraFocus 100.0	The setCameraFocus command controls focus for the camera on the robot side. The value sent is passed "raw" to the video application running on the robot, which interprets it according to its own specification.
setCameraZoom	setCamerazoom 100.0	The setCameraZoom command controls zoom for the camera on the robot side. The value sent is passed "raw" to the video application running on the robot, which interprets it according to its own specification.
shutdown	Shutdown	The shutdown command shuts down the robot and powers down its computer.
stop	stop	The stop command directs the robot to stop moving immediately. It is assumed this will be as sudden a stop as the mechanism can safely accommodate.
timing	Timing 3245629 500	The timing message is used to estimate message latency. It holds the UCT value (seconds + milliseconds) of the time the message was sent, as recorded on the sending machine. To do a valid test, you must compare results in each direction (i.e., sending from machine A to machine B, then from machine B to machine A) in order to account for differences in the clocks between the two machines. The robot records data internally to estimate average and maximum latency over the course of a session, which it prints to log files.

TABLE III-continued

Control Commands		
Command	Example	Description
userTask	userTask "Jane Doe" "Remote Visit"	The userTask command notifies the robot of the current user and task. It typically is sent once at the start of the session, although it can be sent during a session if the user and/or task change. The robot uses this information for record-keeping.

Table IV provides a list of reporting commands that are generated by the robot and transmitted to the remote station through the network.

TABLE IV

Reporting Commands		
Command	Example	Description
abnormalExit	abnormalExit	This message informs the user that the robot software has crashed or otherwise exited abnormally. Te robot software catches top-level exceptions and generates this message if any such exceptions occur.
bodyType	bodyType 3	The bodyType message informs the station which type body (using the numbering of the mechanical team) the current robot has. This allows the robot to be drawn correctly in the station user interface, and allows for any other necessary body-specific adjustments.
driveEnabled	driveEnabled true	This message is sent at the start of a session to indicate whether the drive system is operational.
emergencyShutdown	emergencyShutdown	This message informs the station that the robot software has detected a possible "runaway" condition (an failure causing the robot to move out of control) and is shutting the entire system down to prevent hazardous motion.
odometry	odometry 10 20 340	The odometry command reports the current (x, y) position (cm) and body orientation (degrees) of the robot, in the original coordinate space of the robot at the start of the session.
sensorGroup	group_data	Sensors on the robot are arranged into groups, each group of a single type (bumps, range sensors, charge meter, etc.) The sensorGroup message is sent once per group at the start of each session. It contains the number, type, locations, and any other relevant data for the sensors in that group. The station assumes nothing about the equipment carried on the robot; everything it knows about the sensors comes from the sensorGroup messages.
sensorState	groupName state data	The sensorState command reports the current state values for a specified group of sensor. The syntax and interpretation for the state data is specific to each group. This message is sent once for each group at each sensor evaluation (normally several times per second).
systemError	systemError driveController	This message informs the station user of a failure in one of the robot's subsystems. The error_type argument indicates which subsystem failed, including driveController, sensorController, headHome.
systemInfo	systemInfo wireless 45	This message allows regular reporting of information that falls outside the sensor system such as wireless signal strength.
text	text "This is some text"	The text string sends a text string from the robot to the station, where the string is displayed to the user. This message is used mainly for debugging.

TABLE IV-continued

Reporting Commands		
Command	Example	Description
version	version 1.6	This message identifies the software version currently running on the robot. It is sent once at the start of the session to allow the station to do any necessary backward compatibility adjustments.

The processor **154** of the robot high level controller **150** may operate a program that determines whether the robot **12** has received a robot control command within a time interval. For example, if the robot **12** does not receive a control command within 2 seconds then the processor **154** provides instructions to the low level controller **150** to stop the robot **12**. Although a software embodiment is described, it is to be understood that the control command monitoring feature could be implemented with hardware, or a combination of hardware and software. The hardware may include a timer that is reset each time a control command is received and generates, or terminates, a command or signal, to stop the robot.

The remote station computer **22** may monitor the receipt of video images provided by the robot camera. The computer **22** may generate and transmit a STOP command to the robot if the remote station does not receive or transmit an updated video image within a time interval. The STOP command causes the robot to stop. By way of example, the computer **22** may generate a STOP command if the remote control station does not receive a new video image within 2 seconds. Although a software embodiment is described, it is to be understood that the video image monitoring feature could be implemented with hardware, or a combination of hardware and software. The hardware may include a timer that is reset each time a new video image is received and generates, or terminates, a command or signal, to generate the robot STOP command.

While certain exemplary embodiments have been described and shown in the accompanying drawings, it is to be understood that such embodiments are merely illustrative of and not restrictive on the broad invention, and that this invention not be limited to the specific constructions and arrangements shown and described, since various other modifications may occur to those ordinarily skilled in the art.

What is claimed is:

1. A remote controlled robot system, comprising:

a mobile robot with a robot camera, a plug module including a plurality of electrical contacts, and a movement platform;

a remote control station that transmits commands to control said mobile robot;

a charging module that mates with said plug module, wherein said plug module can pivot relative to said robot about a vertical axis; and,

an alignment system that aligns said plug module with said charging module, said charging module includes a sensor in said plug module.

2. The system of claim **1**, wherein said alignment system includes a plurality of IR emitters in said plug module.

3. The system of claim **2**, wherein said alignment system includes at least one short pass filter in said charging module.

4. The system of claim **1**, further comprising a camera in said plug module.

5. The system of claim **1**, wherein said plug module includes a plurality of electrical contacts that include a short ground contact that has a length shorter than said electrical contacts.

6. The system of claim **1**, wherein said mobile robot includes a male electrical plug that can be plugged into a wall socket.

7. The system of claim **1**, wherein said remote control station displays a display user interface with a graphical icon that can be selected to enable an automatic docking mode.

8. A remote controlled robot system, comprising:

a mobile robot with a robot camera and a movement platform;

a plug module that includes a plurality of electrical contacts including a short grounded contact that has a length shorter than said other electrical contacts;

a remote control station that transmits commands to control said mobile robot;

a charging module that mates with said plug module; and,

an alignment system that aligns said plug module with said battery charging module by permitting said plug module to pivot relative to said robot about a vertical axis.

9. A method for charging a remote controlled robot system, comprising:

providing a mobile robot with that has a robot camera, a plug module including a plurality of electrical contacts that includes a short grounded contact that has a length shorter than said other electrical contacts, and a movement platform;

providing a remote control station that transmits commands to control movement of said mobile robot;

moving the mobile robot until a charging module mates with said plug module, wherein said plug module includes an alignment system that aligns said plug module with said battery charging module by permitting said plug module to pivot relative to said robot about a vertical axis.

* * * * *